UNIVERSITY OF MIAMI

Marine Laboratory

PROCEEDINGS

OF THE

Gulf and Caribbean Fisheries Institute

TWELFTH ANNUAL SESSION

NASSAU, BAHAMAS · NOVEMBER, 1959

Edited by JAMES B. HIGMAN

CORAL GABLES, FLORIDA JUNE, 1960

Gulf and Caribbean Fisheries Institute

Executive Committee

C. P. IDYLL—*Chairman, G.C.F.I.; Chairman, Department of Marine Sciences, University of Miami*

JAMES B. HIGMAN—*Executive Secretary, G.C.F.I.; The Marine Laboratory, University of Miami*

JOHN C. FERGUSON—*President, St. George Packing Company, Ft. Myers Beach, Florida*

HECTOR FERREIRA—*President, Pesquera e Industrializadora de Guaymas, Guaymas, Son., Mexico*

DAVID H. HART—*D. H. Hart Inc., Cape May, N. J.*

JOHN MEHOS—*Liberty Corporations, Galveston, Texas*

L. C. RINGHAVER—*President, Diesel Engine Sales, Inc., St. Augustine, Florida*

JOHN ROBAS—*Commercial Fisheries Consultant, Fernandina Beach, Florida*

A. J. ROBIDA—*President, Florida Fish Distributors, Inc., Jacksonville, Florida*

HARRY F. SAHLMAN—*President, H. F. Sahlman Seafoods Co., Fernandina Beach, Florida*

F. G. WALTON SMITH—*Director, The Marine Laboratory, University of Miami; Executive Secretary, International Oceanographic Foundation*

LAWRENCE W. STRASBURGER—*Food Technologist and Consultant, Metairie, Louisiana*

FRANCIS TAYLOR—*President, Warren Fish Company, Pensacola, Florida*

RICHARD T. WHITELEATHER—*Assistant Regional Director, Bureau of Commercial Fisheries, St. Petersburg Beach, Florida*

DUDLEY WILES—*Fishery Officer, Department of Science and Agriculture, Barbados, B.W.I.*

Additional copies may be obtained from The Gulf and Caribbean Fisheries Institute, The Marine Laboratory, University of Miami, 1 Rickenbacker Causeway, Miami 49, Florida, for $2.00 (Two dollars) per copy.

ML 60052

Contents

Opening Session

THE COMMERCIAL FISHERIES OF THE GULF AND SOUTH ATLANTIC—A REPORT OF PROGRESS, Seton Thompson 1

Shrimp Session

NOTES ON THE MIGRATION AND GROWTH OF PINK SHRIMP (PENAEUS DUORARUM), T. J. Costello and Donald M. Allen 5
LARVAE OF THE PINK SHRIMP (PENAEUS DUORARUM), Sheldon Dobkin 10
BEHAVIOR OF SHRIMP TRAWLS, Harvey R. Bullis, Jr. 10
THE SHRIMP FISHERY OF PANAMA, Luit K. Boerema and Juan L. Obarrio 10
A PLAN TO PROVIDE A LARGER MARKET FOR SHRIMP IN THE UNITED STATES, William R. Neblett 14

Industrial Fisheries Session

HOW INTERNATIONAL FISHERY COMMISSIONS OPERATE TO PROMOTE CONSERVATION OF HIGH SEAS RESOURCES, William C. Herrington 18
FISH AND FEED IN THE SIXTIES, Wayne M. Waller 21
SPORT FISHERMAN - COMMERCIAL FISHERMAN RELATIONS, David H. Hart 26
POTENTIAL MARKETS FOR PRODUCTS OF THE INDUSTRIAL FISHERIES, John A. Holston 28
CONTINUOUS DISTRIBUTION OF MENHADEN ALONG THE SOUTH ATLANTIC AND GULF COASTS OF THE UNITED STATES, John W. Reintjes 31
DEVELOPMENT OF AN AIR-BUBBLE CURTAIN FOR CATCHING MAINE SARDINES, Keith A. Smith 36

Technology and Exploratory Fishing Session

HIGHLIGHTS OF THE SECOND F. A. O. WORLD FISHING BOAT CONGRESS, L. C. Ringhaver 37
RECENT ADVANCES IN SHRIMP TECHNOLOGY, John A. Holston 40

Factors Affecting Yield of Meat from the Blue Crab, C. F. Dunker, D. H. B. Ulmer, Jr. and G. W. Wharton 40
North Atlantic Tuna Explorations, James L. Squire, Jr. 46

Biological Session

Report of the Committee on Oceanography: "What Does it Mean to Commercial Fisheries?", Howard H. Eckles 47
The Effects of Pesticides on Sport Fisheries, Daniel H. Janzen 50
Clay-Mineral Sediments as a Reservoir for Radioactive Materials in the Sea, K. M. Rae and R. G. Bader 55
Commercial and Biological Uses of the Maryland Soft Clam Dredge, J. H. Manning 61
The Biological and Economic Problems in Marine Fisheries Management, Richard Van Cleve 67
Ecological Diagnosis of a Species and the Problem of Biological Constants, G. L. Kesteven and H. Rosa, Jr. 75

Caribbean and General Session

Fisheries Problems in the West Indies, Ernest Hess 88
The Role of Government and Industry in Fisheries Development with Special Reference to Under-Developed Countries, Cecil Miles 94
Current Patterns on the Tortugas Shrimp Grounds, F. F. Koczy, M. O. Rinkel and S. J. Niskin 112
Potential for Developing a Red Snapper Fishery in British Guiana, Francis Taylor 126
Potentialities for an Octopus and Squid Fishery in the West Indies, Gilbert L. Voss 129
Registrants 136

Acknowledgments

The Gulf and Caribbean Fisheries Institute is a non-profit organization supported mostly by The Marine Laboratory of the University of Miami. Additional services, including some of the costs of publishing the Proceedings, are only possible through the generosity of the fishing industry. The following persons and organizations contributed financial help during the past two years, and this is gratefully acknowledged.

Atlantic States Marine Fisheries Commission, 22 West First St., Mount Vernon, N. Y.; J. W. Willis, Crest Importing Co., San Diego, Calif.; Dan B. Vincent, Dan B. Vincent, Inc., Tampa, Fla.; John Robida, Florida Fish Distributors, Inc., Jacksonville, Fla.; J. Roy Duggan, Sea Pak Corp., St. Simon's Island, Ga.; Sam Snodgrass, Brownsville Shrimp Producers Association, Brownsville, Texas; N. E. Gallagher, Detroit Waste Works, Inc., Detroit, Mich.; Cecil H. Fosdick, Gibbs Corp., Jacksonville, Fla.; Wayne M. Waller, H. J. Baker and Bro., New York, N. Y.; Leo D. Levinson, Ocean Products, Inc., Tampa, Fla.; L. C. Ringhaver, Diesel Engine Sales, Inc., St. Augustine, Fla.; W. B. Lewis, Lewis Crab Factory, Brunswick, Ga.; Jack T. Styron, Wallace Menhaden Products, Inc., New Orleans, La.; John Ferguson, St. George Packing Co., Ft. Myers, Fla.; William C. Lunsford, Jr., Reedville Oil and Guano Co., Inc., Wildwood, N. J.; Otis Smith, Fish Products Co., Lewes, Del.; Jack Silverman, Modern Maid Food Products, Inc., Jamaica, N. Y.; Fernand Lapeyre, The Peelers Co., New Orleans, La.; John Rosenberg, Florida Fishermen's Supply Co., Inc., Tampa, Fla.; Clifford V. Varin, Fire Island Sea Clam Co., West Sayville, N. Y.; Max Swartz, East Coast Fisheries, Miami, Fla.; C. S. Yeomans, Coast Fisheries Division, The Quaker Oats Co., Wilmington, Calif.

MONDAY—NOVEMBER 9

Chairman—C. P. IDYLL, *Chairman, Gulf and Caribbean Fisheries Institute, Miami, Florida*

The Commercial Fisheries of the Gulf and South Atlantic — A Report of Progress

SETON THOMPSON
Regional Director, Bureau of Commercial Fisheries
St. Petersburg Beach, Florida

Abstract

This year the Bureau of Commercial Fisheries will complete its research on Atlantic shad, disclosing the cause for the decline in catch, indicating conditions favoring recovery, and providing the basis for future scientific management. Progress also has been made in biological research on shrimp and menhaden. Positive evidence exists that the protected bays of Everglades National Park are important nursery grounds for Tortugas shrimp, and information has been obtained as to rates of growth and routes of migration to the fishing grounds. The causes for fluctuations in the catches of menhaden are still under study. Exploratory shrimp trawling off the northern coast of South America has led to commercial fishing by U. S. flag vessels in those waters. Exploratory operations have demonstrated the feasibility of trawling for red snappers in the Gulf, and have revealed the presence of large schools of herring-like fishes in the midwater zone. A new exploratory operation has been established for the South Atlantic area. Economic difficulties in the shrimp industry, the disposal of atomic wastes in the ocean, and man-made changes in estuarine waters are problems of major concern. The growing interest in oceanography brightens the general fisheries outlook.

IN THESE DAYS OF explosive change, it seems worthwhile to pause long enough to take stock of what is being done and what has been accomplished during the past year through the efforts of the Bureau of Commercial Fisheries in the Gulf and South Atlantic area.

There have been some outstanding achievements of which we are duly proud, and these will be discussed. There are some rather serious problems facing the fishing industry in this area, and these will be described as well as the action taken to solve them. There are some encouraging indications of growing interest in the subject of oceanography, and how the Bureau of Commercial Fisheries fits into this picture is explained below.

All of you have heard the comment that fishery research once started never ends. It has been said that fishery biologists only want more money and more time to continue their research; that they never have conclusive results to report. It can be reported now that research on Atlantic shad is being completed this year. The objectives of this research have been (1) to discover the causes for the decline in the catch from a peak of 50 million pounds near the turn of the century to a low of 8 million pounds in 1950; (2) to determine the conditions that would favor restoration; and (3) to provide information for scientific management of the fishery. All of these objectives have been realized; they are the subject of a number of scientific reports. The States concerned are now in possession of the methods and techniques by which they can properly

manage their shad resources. Except for consulting services for the States, this project will be terminated on June 30.

Good progress is being made on our expanded shrimp research program which has been divided into small segments that can be attacked separately in order of priority. Some of these segments are being completed, and eventually the whole picture will be complete.

At the present time efforts are being concentrated on the Tortugas pink shrimp stocks, and on the browns and whites in the vicinity of Galveston Bay.

The first step in the Tortugas area was to determine the relationship between the size of pink shrimp and the depth of water in which they are found. This study was undertaken for the Bureau by The Marine Laboratory of the University of Miami under contract, and it has been completed with positive evidence that the shrimp move farther offshore and into deeper water as they grow larger. This finding supports the precautionary measure taken by the Florida State Board of Conservation to restrict fishing in certain waters of the Keys when the shrimp are of small size.

The next step in the Bureau's study of Tortugas stocks was to locate their nursery grounds, determine the routes of migration of the young from the nursery grounds to the fishing grounds, and the rate of growth during such migration. You have been told of the technique developed for marking shrimp with vital stains, using hypodermic needles for injecting the juveniles on the nursery grounds. With this technique, Bureau biologists have been able to mark many thousands of young pink shrimp in the protected bays of Everglades National Park. In their subsequent migration, they have been taken in small numbers on the fishing grounds and have been positively identified. Thus, it has been established that the estuaries of Everglades National Park are important as nursery grounds for the Tortugas shrimp, and information has been gained that in their migration to the fishing grounds, 100 miles or more to the west, shrimp triple their weight in a matter of four months. Present experiments are under way to stain another 90,000 or so small pink shrimp to verify these results and obtain additional information, including the natural mortality of the species.

In the Texas area the Bureau is adding to the fund of knowledge of both white and brown shrimp by using similar techniques. By staining the young on the nursery grounds in Galveston Bay, valuable information is being obtained on routes of migration to the fishing grounds, and rates of growth and mortality. It has been learned, for example, that young brown shrimp from Galveston Bay can travel as far as 25 miles in one week, and several have been taken offshore as far as Freeport, 50 miles away.

The Marine Laboratory of the University of Miami is working for the Bureau on another phase of the shrimp life history in the Tortugas area. This concerns the inshore movement of the pink shrimp, and requires identification of its several larval and post-larval stages, as well as the mechanism by which they are carried to the estuarine nursery grounds. Excellent results are being obtained and will be reported during this program.

Research work on menhaden also is progressing well. This species accounts for about one half of all the landings on the Atlantic coast and ranks first in volume of all commercially caught fish and shellfish in the United States. Despite its enormous yield, the menhaden fishery, as most of you know, has had its ups and downs. Seasons of scarcity and abundance have occurred in this fishery from its very beginning. Research on this species is designed to

determine why such fluctuations occur so operations can be geared to the available supply.

The Bureau has learned a great deal about Atlantic menhaden in the five years this research has been going on. Briefly, it has been found that (1) the Atlantic coast fishery is supported by a single species of menhaden; (2) estuarine nursery grounds, as in the case of shrimp, are an essential link in the life of this species; (3) different age and size groups make up the catches in different areas; and, finally, (4) variations in the brood strength from year to year appear to be the chief source of fluctuation in the catch.

Exploratory fishing by the Bureau has provided some useful and exciting information. Discovery of shrimp in commercial quantities along the northern coast of South America was put to immediate use, and several U.S. flag vessels are now working in that area. The feasibility of commercial trawling for red snappers in the Gulf of Mexico has been demonstrated, and the way has been opened to extend the area for harvesting industrial fish in the northern Gulf. The fish are there, and modified trawling gear can take them.

There is reason for excitement in the known existence of schools of herring-like fish of tremendous size in the midwater region of the Gulf. Equipped with the most modern electronic devices, our vessels have recorded schools 20 miles long and 10 miles wide. This is the potential for a new fishery when more is known of the seasonal and geographic distribution of these schools, and methods are developed for capturing them.

You will be pleased to know that the Bureau has at last been able to finance an exploratory fishing operation in the South Atlantic area. This activity will be based at Brunswick, Georgia, so that it can be coordinated very closely with the oceanographic research in progress at our biological laboratory there. The Atlantic States Marine Fisheries Commission has urged that this work be undertaken for several years. The complete disappearance of the brown shrimp after they pass through the fishery in coastal waters is one of the mysteries it is hoped this investigation will solve. Information also will be sought as to the availability of industrial fish, and the commercial potential of hard clams and scallops.

The Bureau of Commercial Fisheries has instituted an inspection service, and voluntary quality standards are now available for certain items. Continuous plant inspection entitles the producer to identify his product with a shield certifying quality comparable to the Department of Agriculture's seal for meat. This service gives our industry a definite and exclusive competitive advantage over imported fishery products, and it should be used to the fullest extent.

Seldom is it all smooth sailing when dealing with fish and fisheries, and right now there are a few real problems that should be mentioned. First, there is the unhappy situation in the shrimp industry. It seems almost paradoxical that the industry producing the most valuable fishery product in the United States should be experiencing economic distress. Nevertheless, there are danger signals. For example, cold storage holdings of shrimp have been much larger than normal, in fact, almost double and, along with this, shrimp imports have climbed to a new high. Eighty-five million pounds of shrimp came into the United States last year from almost 50 countries, and the trend this year has been upward. Add to these the sharp break in prices and the distress signal becomes emphatic.

This problem is being met head-on. First, the facts must be determined. What are the trouble spots in the industry, and how can they be corrected? This calls for an economic study of the industry, and one is in progress now. While

this study is being made, other things are being done to provide relief. The first and probably the most obvious is a market promotional effort. In cooperation with the industry, the Bureau's market development specialists are emphasizing shrimp in their contacts with institutional outlets, food editors, radio and press representatives, and trade organizations. Shrimp was in the spotlight in the annual Fish 'n' Seafood Parade, and will receive similar treatment during the Lenten promotional effort.

Diversification in fishing would provide stability to the shrimp fleet in off-season periods, and substitute employment in times of adverse markets. Alternative fishery resources available to shrimp vessels are being pinpointed by Bureau exploratory operations. Specialists in fishing, technology of meal and oil manufacture, and marketing have teamed up to discuss these alternative operations with representatives of the shrimp industry.

Another problem of real importance to the fishing industry is that having to do with the disposal of atomic wastes in our coastal waters. This has been the subject of inquiry by the National Academy of Science; and extensive hearings have been held by the Joint Congressional Committee on Atomic Energy. This Committee is holding additional hearings in major coastal cities so that all interests may express their views. The Bureau of Commercial Fisheries has taken a positive stand on this matter. Namely, (1) the ocean should be used as little as possible for disposal of atomic wastes or other unwanted materials; (2) if the ocean is to be used for disposal, it should be done according to a well-designed plan; (3) areas should be selected for disposal which will not harm other interests; (4) their numbers should be kept to a minimum; (5) they should be well marked; (6) their existence should be publicized; and (7) all disposal operations should be policed closely.

Unless these conditions for disposal of atomic wastes are met, the Bureau of Commercial Fisheries would be opposed to disposal in the sea.

The next problem which confronts all of us is not a new one. But it is still with us. This is the problem of the many man-made changes in our coastal waters which are so essential to some of our most valuable fish and shellfish. These resources have more to fear from the type of coastal development now being carried on than from the commercial fishermen. Both the Gulf States Marine Fisheries Commission and the Atlantic States Marine Fisheries Commission have named committees to work on this problem.

On the brighter side, the Committee on Oceanography of the National Academy of Science, in its report to the President, brought into sharp focus the importance of the oceans to the well-being of this country, and the need for a better understanding of them. The details of this report will not be explained here, because you are to hear more about it later in the program. I think it is sufficient to say at this time that if these recommendations are carried out, the research programs for shrimp, menhaden, blue crab, estuaries, and many others, will be fully activated. This is most encouraging, indeed.

From all of this, you can see that the Bureau of Commercial Fisheries is vigorously striving to do the job called for—cooperation with the State Conservation agencies to provide the basis for sound resource management and assistance to the fishing industry so that it may continue to hold its rightful place in our economy.

MONDAY—NOVEMBER 9

Chairman—JOHN FERGUSON, *President, St. George Packing Company, Ft. Myers Beach, Florida*

Notes on the Migration and Growth of Pink Shrimp (Penaeus duorarum)

T. J. COSTELLO AND DONALD M. ALLEN
U. S. Bureau of Commercial Fisheries

PINK SHRIMP, *Penaeus duorarum*, of the Tortugas grounds in the Gulf of Mexico support an intensive and valuable fishery prosecuted by the United States and Cuba. As in the case of any renewable resource, its management requires knowledge of population distribution and growth. Systematic mark-recovery experiments being conducted by the U. S. Bureau of Commercial Fisheries are proving a practical means for obtaining such information. The shrimp-marking techniques involve the use of biological stains and were described by Dawson (1957) who pioneered their development. A preliminary mark-recovery experiment to test the field use of biological stains was executed in Biscayne Bay, Florida, in early 1958 (Costello 1959).

In seeking to define nursery grounds necessary in the life history of Tortugas pink shrimp, it was noted that Iversen and Idyll (1960) gave evidence that inshore waters along the south Florida coast potentially represented such areas. These authors also report the recovery of a shrimp on the Tortugas grounds which was tagged and released at Coot Bay in the Everglades. Tabb (in press), in describing this extensive estuarine system, pointed out that juvenile pink shrimp are commonly found here in great abundance. This suggested that the periphery of Florida Bay afforded the most logical sites from which to conduct large-scale mark-recovery experiments to delimit the habitat of shrimp contributing to the Tortugas fishery.

From October 1958 to March 1959 three groups of juvenile pink shrimp were stained and released at three locations in Florida Bay (Figure 1). Shrimp catches from the Dry Tortugas and Sanibel grounds were examined for possible recoveries and checks were made of shrimp taken from the Tampa area, Biscayne Bay, and the fishery south of Marathon. Experiment specifications and results are given in Table 1.

Migrations

Recoveries of stained shrimp show that shrimp from the Flamingo nursery area contribute to the Tortugas commercial catch. The first verified[1] recovery had moved at least 90 miles in 85 days. However, the route of these shrimp to the Tortugas grounds is open to conjecture. The Fish and Wildlife Service sta-

[1]Verified recoveries include shrimp taken in the fishery, returned, and identified as shrimp stained with a biological stain; unverified recoveries include stained shrimp noted by fishermen and reported but not returned for identification and verification.

TABLE 1

SHRIMP MARK-RECOVERY DATA: FLORIDA BAY - TORTUGAS AREA, 1958-1959

Release Information	Tortugas Grounds Recovery Information			
	Location	Date	Carapace length in mm	Sex
Flamingo Date: 10/24/58 to 10/31/58 No. released=7,264 Carapace length=13.2 - 21.6 mm Mean=16.7 mm	N of "B" Buoy in 14 1/2 fms.	1/20/59	25.1	M
	NW of "D" Buoy in 13 fms.	1/28/59	26.0	F
	NW of Wreck Buoy in 17 ms.	2/5/59	33.0	F
	1 1/2 mi. NE of Pulaski Light in 17 fms.	2/26/59	29.1	M
Peterson Keys Date: 1/29/59 No. released=1,729 Carapace Length=15.4 - 26.7 mm Mean=19.7 mm	1-1 1/2 mi. N of Smith Shoals Light	3/16/59	23.0	F
	W of "C" Buoy in 13 fms.	3/22/59	23.2	F
	10 mi. NW of Wreck Buoy in 12 2/3 fms.	3/22/59	21.5	M
	NE of "C" Buoy in 12 2/3 fms.	3/24/59	24.3	M
	NE of "C" Buoy in 12 fms.	3/26/59	24.2	F
	NW of Wreck Buoy in 13 fms.	4/7/59	22.5	F
	NNW of "A" Buoy in 15 or 15 1/2 fms.	4/12/59 or 4/13/59	21.0	F
	Between "A" & "B" Buoys in 15 fms.	4/22/59	28.0	F
	3-4 mi. ENE of "A" Buoy in 14 fms.	4/28/59	23.1	M
	N of "A" Buoy in 16 fms.	5/1/59	24.5	M
	NW of "D" Buoy in 10 1/3 fms.	5/2/59	30.5	F
Lower Matecumbe Key Date: 3/6/59 No. released=1,672 Carapace length=17.3 - 26.4 mm Mean=20.5 mm	No recoveries to date			

tistical agent at Key West reported that a shrimp stained[2] blue had been "definitely" caught in Hawk Channel, in the Atlantic Ocean southwest of Marathon, Florida, in January 1959. This might indicate that shrimp from the Flamingo area move south through the Keys into Hawk Channel, and then westward to the Tortugas grounds. Higman (1952) reported that large catches of shrimp were made from the Keys' bridges, caught on the outgoing night tides, generally during the winter months. These catches suggest that quantities of shrimp leave Florida Bay by passing through the Keys to the Atlantic Ocean. Once outside, it is only a short distance to Hawk Channel, certain parts of which support a seasonal commercial shrimp fishery.

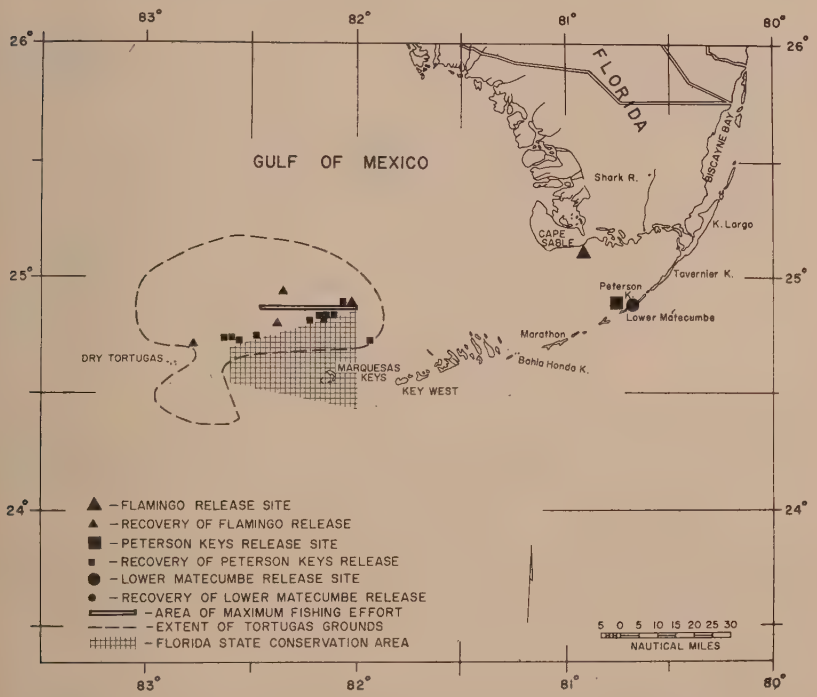


FIGURE 1. Migration of pink shrimp as shown by marking experiments.

Shrimp marked and released at Peterson Keys were also recovered on the Tortugas grounds. The first Peterson Keys recovery was made on the Tortugas grounds 47 days after release compared with 85 days for the first Flamingo recovery. The four verified recoveries of shrimp released at Flamingo averaged 99 days "out time" whereas the eleven recoveries of shrimp released at Peterson Keys averaged 69 days "out time." These release sites are, roughly, equidistant from the center of the area in the Tortugas grounds where all the stained shrimp were recaptured. This difference in "out time" suggests the possibility that

[2]Blue color was used on shrimp released at Flamingo.

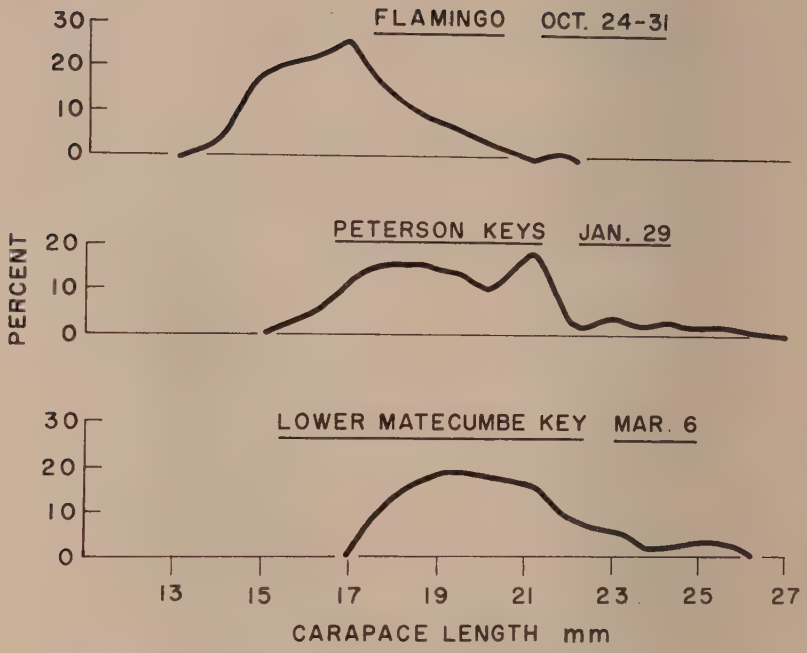


FIGURE 2. Size range of stained shrimp.

shrimp released at Flamingo did not move directly off-shore, but perhaps moved southward, and followed a migration route similar to that of shrimp passing through the Keys.

The Lower Matecumbe Key release site is located about three miles southeast of the release site at Peterson Keys (Figure 1). Approximately the same number of shrimp were released in both locations, but the Lower Matecumbe Key releases were made 36 days later. No shrimp released at the latter site have been recovered.

Growth

Estimation of growth rates requires knowledge of the size composition of the stained shrimp released. Equipment was devised and used to separate shrimp lying within the size range chosen for staining. "Random" samples of shrimp being stained were measured to determine the size composition of the group released. Figure 2 depicts the size composition of stained shrimp released at each of the three Florida Bay sites.

Recoveries are still too few to accurately determine growth rates of juvenile pink shrimp as they move offshore. In view of the scarcity of other growth data for Tortugas shrimp, the accompanying information may be of value. Growth is calculated from the mean carapace length[3] at release. For the Flamingo

[3]Carapace length is a head-length measurement taken from the orbital notch inside the orbital spine in a line parallel to the lateral rostral sulcus to the posterior margin of the cephalothorax.

release (four recoveries) mean growth in terms of carapace length was 3.5 mm per month, a decrease from 240 to 108 count per pound, heads off. For the Peterson Keys release (eleven recoveries) the mean growth per month was 1.9 mm, representing a decrease from 138 to 96 count, heads off. These figures indicate respectively winter and early spring growth and therefore may approach minimum expected growth. Williams (1955) found that pink shrimp in North Carolina estuaries grew slowest in winter. For shrimp having an initial mean total length of approximately 42.5 mm, he estimated growth in terms of increasing total length to be 7.5 mm per month, for the period November to April. Converted to carapace length, this represents growth of approximately 1.6 mm per month from an initial mean carapace length of 9.2 mm.

Discussion and Summary

Fifteen verified recoveries of marked shrimp released in Florida Bay suggest the relative importance of certain areas as nursery grounds for the heavily exploited Tortugas pink shrimp. Previously, the only evidence linking the Florida Bay estuaries to the Tortugas grounds was the single tagged shrimp recovery reported by Iversen and Idyll (1960).

The useful information obtained attests to the utility of marking shrimp with biological stains. The method appears particularly suited to experiments which require observations over periods of several months.

Though the data on migrations and growth are preliminary in nature, they will serve as the basis for more extensive investigations. The three mark-recovery experiments reported comprise a first step in delineating the areas which contribute to the maintenance of the Tortugas shrimp population.

ACKNOWLEDGMENTS

We appreciate the assistance and advice of Mr. A. J. Mills, bait shrimper, Tavernier, Florida; Mr. Warren Hamilton, Superintendent of Everglades National Park, and his staff; and Mr. Durbin Tabb, Research Instructor, University of Miami Marine Laboratory.

LITERATURE CITED

Costello, Thomas J.
1959. Marking shrimp with biological stains. Proc. Gulf and Carib. Fish. Inst., Eleventh Ann. Sess., pp. 1-6.

Dawson, C. E.
1957. Studies on the marking of commercial shrimp with biological stains. U. S. Fish and Wildlife Service, Spec. Sci. Rept.—Fish. No. 231, 23 pp.

Higman, J. B.
1952. Preliminary investigation of the live bait shrimp fishery of Florida Bay and the Keys. Rep. Mar. Lab. Univ. Miami to Fla. State Bd. Conserv. 8 pp. (Mimeo.).

Iversen, Edwin S. and C. P. Idyll
1960. Aspects of the biology of the Tortugas pink shrimp, *Penaeus duorarum*. Trans. Amer, Fish. Soc. *89* (1): 1-8.

Tabb, Durbin C.
In press. An ecological study in a south Florida estuary. Trans. Amer. Fish. Soc.

Williams, Austin B.
1955. A contribution to the life histories of commercial shrimps (Penaeidae) in North Carolina. Bull. Mar. Sci. Gulf and Carib. *5* (2): 116-146.

Larvae of the Pink Shrimp (Penaeus duorarum)

SHELDON DOBKIN
The Marine Laboratory
University of Miami

THIS RESEARCH was performed under contract with the Bureau of Commercial Fisheries. The results will be published by this agency.

Behavior of Shrimp Trawls

HARVEY R. BULLIS, JR.
U.S. Bureau of Commercial Fisheries

THIS PRESENTATION was a verbal commentary on a moving picture. The 16 mm. underwater color film may be obtained on loan from the Pascagoula Fishery Laboratory, P.O. Box 630, Pascagoula, Mississippi.

The Shrimp Fishery of Panama

LUIT K. BOEREMA
F. A. O. Fishery Officer in Panama
AND
JUAN L. OBARRIO
Director of the Laboratorio Nacional de Pesca, Panama

THE FISHERY is located on the Pacific coast of Panama and is mainly exercised within the Gulf of Panama. It started around 1950 with about eight ships and increased rapidly until about 200 vessels were fishing in 1958.

The shrimp landings have risen quickly, together with the rise in number of boats. Because nearly all shrimp are exported, Table 1, giving the exports, demonstrates the development of the fishery. This table suggests a favorable growth but the fishery has become less profitable, especially in the last few years.

The white shrimp has always been the most important type of shrimp in our fishery. However, the big increase in the exports in recent years has been mainly due to *Xiphopenaeus riveti,* the seabob, a much less valuable species. Red shrimp, also occurring in this region, have until very recently only been fished in the dry season, mainly in February and March, in greatly varying quantities. The red shrimp have been partly responsible for the high exports in 1957.

Because white shrimp always have been of preponderant importance, and the landings of this type of shrimp have not increased proportionally with the increase of the fleet, the Panamanian research activities have been concentrated on this group of species. M. D. Burkenroad in 1954 initiated, and during a number of years guided, the collection of information on various aspects of the fishery and biology of white shrimp.

A detailed analysis of the statistical information has been started this year, but has not yet reached its final stage.

For the purpose of this meeting, preliminary estimates of some main statistical data have been made. It should be stressed that these estimates are not

exact, and that all figures presented in this paper are provisional and subject to revision. However, they will be sufficiently close to give a picture of the situation and the problems involved.

The increase in number of boats has been mentioned already. The average number of boats fishing each year has been included in Table 1. Because the boats added to the fleet in the later years were on the average of a larger size, and because of some improvements in fishing technique, it is probable that the fishing intensity increased even more than the number of boats indicates.

TABLE 1

PANAMA—NO. OF BOATS FISHING, AND SHRIMP EXPORTS, IN THE YEARS 1950-1958. (DATA ON EXPORTS OBTAINED FROM THE CONTRALORÍA GENERAL DE LA REPÚBLICA, PANAMA).

Year	Average number of boats	Exports in '000 pounds
1950	10	305
1951	33	1,241
1952	70	2,414
1953	86	4,814
1954	85	3,554
1955	85	4,233
1956	105	5,977
1957	162	8,263
1958	205	7,958

Fairly close estimates of the total landings of white shrimp are given in Table 2 (no estimates could be made of the landings in the years before 1954). The table shows an increase of the landings from 1955 to 1956, but no further increase took place after 1956. Data available so far from 1959 suggest that the landings in this year will not surpass the quantity of 1956.

TABLE 2

QUANTITIES OF WHITE SHRIMP LANDED IN PANAMA

Year	Quantity in million pounds
1954	3.3
1955	3.3
1956	4.5
1957	4.2
1958	3.7

As a result the catch per boat has shown a considerable decline. The average catch per boat per day in one of the main fishing areas, calculated for boats of sizes between 50 and 60 feet, gives a picture of this decline, which reflects the decrease in density of the shrimp stocks (Table 3).

Although the fact that the increase in fishing intensity was accompanied by a decrease in the catches per boat suggests that the fishery itself has caused this decrease, it still is possible that natural circumstances are mainly responsible for the decline in the shrimp stocks, and therefore for the lower catches.

If the fishery has a great effect upon the stocks, it may theoretically be ex-

TABLE 3

AVERAGE CATCH PER DAY'S ABSENCE, OF WHITE SHRIMP IN THE AREA EAST FROM PANAMA CITY, CALCULATED FOR SHIPS OF 50-60 FEET LENGTH.

Year	Catch/day (pounds)
1955	273
1956	233
1957	135
1958	61

pected that this is reflected in a decrease in the size of the shrimp caught. A study of the length composition of the catches might help in the explanation of the decrease.

Samples of the commercial landings have been collected since 1955 to obtain information on the length—and species—composition of the catches of white shrimp. From these samples, it was found that white shrimp in Panama include

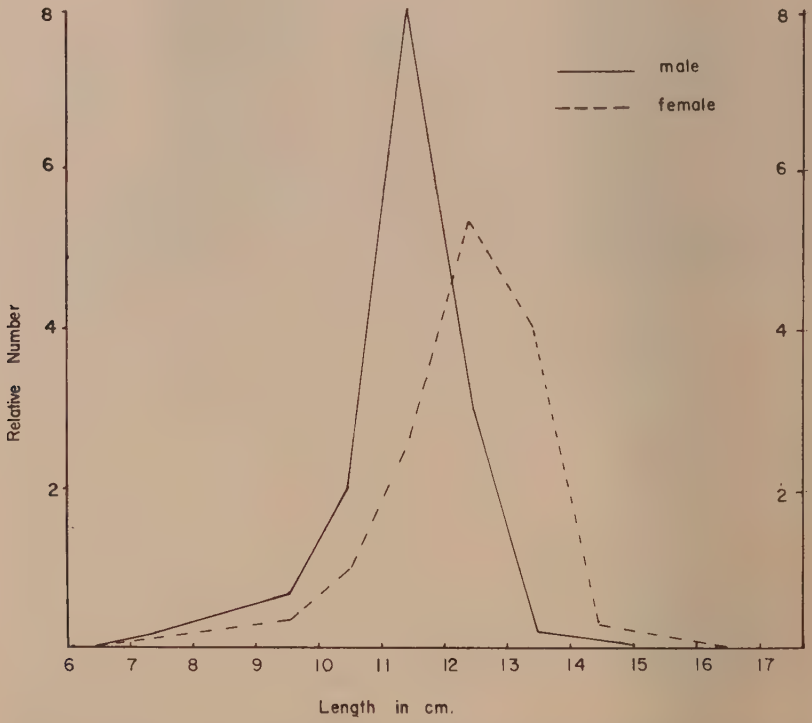


FIGURE 1. *Penaeus occidentalis*—relative length composition of 1955 landings from the area east from Panama City (tail lengths).

three and sometimes four, species: *Penaeus occidentalis, P. stylirostris, P vannamei* and sometimes *P. californiensis*. The samples showed that the species composition is different in different areas. *P. occidentalis* makes up around 90 per cent of the white shrimp catches in the main shrimp area, which is situated in the Gulf of Panama east of Panama City, and around 60 to 70 per cent in the area west of Panama City. About 80 per cent of the white shrimp landings consist of this species.

Only the length composition of *P. occidentalis* will be discussed here.

Figure 1 gives a fairly representative graph of the length distribution of the landings in 1955. The graph shows a steep rise towards the mode, and a steep decline at sizes larger than the mode. The shape of the curve is not affected by rejection; practically all white shrimp caught are landed. This means that at sizes below the mode the fishing mortality is very much lower than at the greater sizes. It is only within a very limited size range, and accordingly during a small part of the life span, that *P. occidentalis* is exposed to the full fishing intensity. And within this size range the numbers show a high rate of decrease with increase in length. Provisional data of the length distribution of the landings in the years 1955-1957 did not show a change in the sizes landed. The analysis has to be completed in more detail before definite statements can be made. The peculiar shape of the length composition curve may show that even an intensive fishery has only slight influence on the length composition of the catches. However, the available data on length composition have not definitely demonstrated that the fishery really has caused the decline in the catches. The analysis will be continued, and it is hoped that in the near future field experiments can be started, including a tagging program.

One other approach which may help in the interpretation of the data is a comparison of the course of the fishery in various countries. Mr. R. W. Ellis, F.A.O. Fishery Officer in Ecuador, has provided data on the shrimp fishery in that country. The species fished are the same as in Panama. A detailed analysis of the statistics is being made, but are not yet available. However, a table of the number of boats fishing and the total exports, comparable with our Table 1, is given in Table 4. In Ecuador, the landings of seabob seem not to have increased to such an extent as in Panama, with the effect that the exports are not so much affected by this species. Therefore, the table gives a general picture of the white-shrimp fishery. It appears that, just as in Panama, the increase in the number of boats has not been accompanied by a similar increase in landings, with the effect that the landings per boat have decreased considerably.

It will be very interesting to compare the data presented here with those of

TABLE 4

ECUADOR—NO. OF BOATS FISHING, SHRIMP EXPORTS, AND CATCH PER BOAT IN THE YEARS 1955-1958.

Year	No. of boats	Shrimp exports (in '000 pounds)	Average catch per boat ('000 pounds)
1955	18	2,307	128
1956	30	2,895	99
1957	60	4,067	68
1958	120	4,438	37

neighboring countries where the development of the fleet has shown a different picture in these years. Those data, however, are not yet available.

Mr. Ellis is now working in Guatemala and El Salvador. It is the intention to adopt standard methods in the shrimp research programs in each of the countries concerned, to obtain comparable results. It is hoped that further regional cooperation will develop in the future.

A Plan to Provide a Larger Market for Shrimp in the United States

WILLIAM R. NEBLETT
Executive Director, National Shrimp Congress

AT THIS MOMENT the shrimp industry is faced with many vexing problems. Not since the low year of 1954 have there appeared to be so many difficulties.

From a point of very low production just a few months ago, we are now entering a better production period, only to be met with very low ex-vessel prices. No one in his right mind would want to see shrimp at a dollar a pound again. The reaction is too violent in the opposite direction when buyers balk and prices plummet downward. However, the fisherman must receive a living wage and have an opportunity to pay his insurance and amortize his investment. This depends on a fair price for shrimp boatside.

A third problem is the over-supply of boats. Efforts are now being made to find diversification for some boats in the production of trash fish, meal, fish oil, etc., but this is slow going. Where 300 boats could make a living, say at Tortugas, 600 boats just divide the same catch, so the catch-per-effort drops to make it uneconomical for all hands. In the normal course of events, we shall again resume the replacement of aging and obsolete vessels.

The unrestricted flood of imports from almost 50 different countries has increased inventories and served as a fulcrum to further depress prices and make the future more unstable. The National Shrimp Congress has sponsored legislation seeking to provide for an orderly development in shrimp imports over the years. This is not aimed at those friendly neighboring countries which have helped the United States producer to build the U. S. market. Shrimp are so universal that almost any country which may decide that it needs U. S. dollars can take its shrimp, perhaps now being used to furnish necessary protein food for its hungry people, and dump them on our market for that desirable dollar. And they may take that dollar and buy radios from West Germany, but our free-traders merrily have ignored this significant situation until just recently. But it is obvious that these under-developed countries can find labor at nine to thirty cents a day, or better-developed countries can subsidize their own industries, as has Japan, to drive the American producer out of business and eventually take over the market under their own terms and conditions. Such a procedure would not be new in this rough international fish business.

When the supply of shrimp is unusually light, exceptional profit-making opportunities bring the butcher, the baker and the candle-stick maker into the business—more vessels, new firms, new plants. Then we achieve a reduced catch per operating unit, because no new grounds are really available for exploitation.

The shortage of shrimp inflates the price and makes shrimp a *luxury* item instead of an every day *staple* of food. For the shrimp industry to prosper, it is necessary for shrimp to become—and *remain*—a *needed* food.

The economists give us a two-pronged formula for prosperity: (1) increase the efficiency of operations, making for net savings, and (2) stabilize the market.

When the consumer resists high prices, decreased consumption results, and it is hard to lure him back. The secret is to keep the customers you have and add more. It is a matter of handling *volume.*

Per-capita consumption of shrimp has doubled since 1930, and the trick is to increase this per-capita consumption by keeping shrimp out of the luxury class and by making it as familiar as bread and milk in the household.

In general, the objective of the industry should be: to supply the consumer with a high-quality product at prices low enough to encourage consumption, but at the same time making it profitable for the fisherman, boat owner, wholesaler and processor. Seasonal supply and periods of high inventories must be met by stepped-up advertising and promotion to promote faster turnover.

Some thought should be given to the establishment of futures trading in shrimp products. Hedging on a commodity exchange tends to reduce fluctuations in price due to seasonal ups and downs.

Provided that prices remain on a level which do not engender consumer resistance, per capita consumption of shrimp will continue to rise.

The primary and basic characteristic of shrimp marketing is flexibility. To cope with the vagaries of the market for a highly perishable product, sellers must be able to shift quickly from one outlet to another. Therefore, the regular flow of communications between market and producer is of great importance.

Now we have a number of good reasons for an expanded market. What is being done, and what more can we do?

We are all aware of the fine promotional work being done by the Shrimp Association of the Americas and by the National Fisheries Institute. Also, some of the pennies in the spread between ex-vessel prices and the consumer are also used by processors and retailers in advertising campaigns. It is readily admitted that this may serve to sell brand names of particular processors, but it is all helpful in the sale of shrimp — making the public more aware of the product.

Hard times seem to beget harder times. I am told that SAOTA is having difficulty meeting its advertising budget, just when you need *more* money and *more* effort. Whatever further sacrifices can be made by industry in this direction should be made, because it is an over-all comprehensive program which helps every single person connected with the shrimp industry. Every producer should give twenty-five cents per box, as a minimum, towards this splendid promotional work. Perhaps some of the free-loaders who have profited from the fine work for years could now come forward and donate one box of shrimp to bolster up this advertising fund. Industry must help itself, and must prove to Government that it *is* helping itself before Government can be persuaded to come to the rescue.

Government is not unmindful of the plight of the shrimp industry. They are making official surveys and studies. They are working, this very minute, in the Bureau of Commercial Fisheries, on budgets and appropriations to present to Congress next year to help industry. We hope and pray that it may not be "too little and too late."

It was our friendly Bureau of Commercial Fisheries which sponsored a meeting of representatives of the shrimp industry in New Orleans on October 30, 1959, to show us what they were now doing about marketing and promotion, and to ask us how they could do more. It is doubtful whether most of you are aware of the great effort and attention being given to shrimp marketing by this Bureau. Government gets free time on television and radio, as a "Public Service." The Bureau of Commercial Fisheries can obtain cooperation from the Department of Agriculture for valuable promotional "tie-ins" with other food products. The field staffs of the Bureau have a close association with State extension services, state and national restaurant associations, school lunch supervisors, the military departments and many other associations and agencies. From the Government printing office come attractive folders, recipes and other promotional material. They issue press releases which reach a special and exclusive field. They prepare exhibits and pamphlets for distribution at national food conventions. They have trained and specialized marketing experts, and they have home economists and other staff personnel in the field, in close contact with the public.

Examples of the help of the Bureau of Commercial Fisheries to the shrimp marketing program are legion. A few are mentioned:

(1) The appearance of Assistant Secretary of Interior, Ross Leffler, on the Don McNeil Breakfast Club on October 14, 1959—an audience of 30 million people heard the emphasis on shrimp; the facts of lowered cholesterol in the blood because of eating shrimp. It would have cost industry $8,000.00 for this radio time.

(2) The two films, "Shrimp Please" and "Shrimp Tips from New Orleans," shown widely throughout the United States on television.

(3) The printing of 50,000 copies of Test Kitchen No. 7—"How to Cook Shrimp."

This and other types of shrimp market promotion have been scheduled by the Bureau through 1960. At the recent New Orleans meeting, your representatives from the Shrimp Industry passed a resolution, which, after all the whereases, said, in part: "Recommends . . . that the Bureau of Commercial Fisheries is strongly urged to increase and intensify its program for shrimp marketing *on an emergency basis,* using any emergency or other funds presently available, and planning and budgeting for further funds to finance expanded programs which will help to alieviate the present plight of the Shrimp Industry and will help to restore it to a healthy position in the U. S. economy . . ."

It is urgent that each shrimp association direct a similar resolution to the Secretary of Interior, emphasizing the need for an expanded shrimp marketing program, so that this department may be armed with suitable requests and resolutions to justify the use of Federal funds in this connection.

This Federal program is not designed to pre-empt the field, and industry will get little sympathy from Washington unless it, too, is making strenuous efforts to help itself. We have touched on industry itself, the Federal government—there remains the area of state activity.

Let me tell you about the increased interest and activity in the states. Chairman Ringhaver, of the National Shrimp Congress, received a latter dated October 26, 1959, from the Honorable Ross R. Barnett, Governor-elect of the State of Mississippi. It says, in part: "The industry is indeed in a bad plight at this time. I hope that Congress will place a graduated control on the imports,

which should give some help to our Gulf Coast. As Governor-elect of Mississippi, I am going to work untiringly with the seafood industry on the Mississippi Gulf Coast in an effort to get it revitalized and back in the position it once held. I would like to have your suggestions as to how you think it should be done . . ."

That man is a statesman, and also a "state's man." And for what a state can do for its shrimp industry, particularly in the promotion and pushing of the product, let us turn now to a brilliant plan being evolved by the Southeastern Fisheries Association.

Florida has a "Citrus Code" for its quarter-billion citrus industry. It came about upon the suggestion of the citrus industry itself. It became state law. The citrus industry is run by a board or commission composed of producers and processors who best know their own problems. The most important features of the plan are:

(1) Standards and inspection, guaranteeing a good, uniform product.

(2) Regulation by industry itself, in effect.

(3) Large appropriations for advertising and promotion.

(4) No cost to the state—expenses borne by industry, but *everybody* in industry—no free-loaders.

Why not, asks Southeastern, a "Seafood Code" on the same general pattern? The potential for advertising is in the hundreds of thousands of dollars. TV, radio and newspaper advertising cost money. Here is a source for a well-planned market promotion program which will increase the demand for the product, guarantee the consumer a standard of quality and grading, and in turn assure a more stable market for the producer and processor. What Florida and California have done for the orange and grapefruit can be done for shrimp and seafood.

I commend this plan to the governor-elect of Mississippi, and to Texas and Louisiana and North Carolina and Georgia and other shrimp-producing states. No legislature should hesitate to help an industry help *itself*. I commend a study of this plan by the Gulf States Marine Fisheries Commission and the Atlantic States Marine Fisheries Commission. These inter-state compact groups are ideal media to work out model legislation and to coordinate their respective member states in the passage of similar state legislation.

Imagine the impact of such joint effort, resulting in uniform standards of the product, with ample funds to spend in the promotion and advertising of shrimp and seafood!

But this program is not available today. It is in the blueprint stage. Some legislatures, as in Florida, will not meet until 1961. But it is a goal to be attained, and makes for a brighter future.

Meanwhile, though the hour be dark, and times are troubled, let us realize firmly that the problem is our own, regardless of Government or other sympathy or help. Through our trade associations we can make our joint efforts count mightily and we can work as one undivided and powerful entity to resolve these problems, with the ingenuity of American genius and the resolution and perseverance of our pioneer ancestors. Thus may we come to educate our fellow Americans to the truths of the values of shrimp as a food, and in so doing create an expanded market for our product.

TUESDAY—NOVEMBER 10

Chairman—WILLIAM C. LUNSFORD, JR., *Executive Vice President, Reedville Oil and Guano Company, Wildwood, New Jersey*

How International Fishery Commissions Operate to Promote Conservation of High Seas Resources

WILLIAM C. HERRINGTON

The Special Assistant for Fisheries and Wildlife to the Under Secretary of State, Washington, D.C.

THE UNITED STATES for many years has been a member of a number of international fishery commissions, but until very recently none of these covered stocks of fish in this part of the country. As many of you know, the United States and Cuba recently negotiated and ratified the Tortugas Shrimp Convention. Organization of the Commission provided for by the Convention awaits the pending appointment of Commissioners to represent each country. Since this is a new type of fishery organization for this area, perhaps you would find it of interest to hear something about other commissions of this general type. What are these international fishery commissions? Why do we have them? What do they do?

It could be said without question that international fishery commissions have provided an excellent training ground for many of our fishery experts. A number of such experts who received their early training from one or another of our fishery commissions are present in this audience. I myself spent the first three years out of the university with the International Pacific Halibut Commission. However, if the sole accomplishment of international fishery commissions was the training of fishery experts it would not be possible to keep the United States Government and the United States Congress interested in financing these organizations year after year. Let us proceed then to some of the other reasons why the United States Government is interested in so doing.

Generally the fishery commissions have originated from situations where intensive fishing or other destructive factors have drastically reduced stocks of fish exploited jointly by United States and foreign fishermen and the concerned United States public was sufficiently interested in the problem to seek government assistance. Generally it seemed evident that conservation measures were needed and that such measures must be enforced equitably on the fishermen of all the nations participating in the fishery. International cooperation thus became necessary since one nation cannot impose its regulations on the fishermen of another nation on the high seas. The basis for such uniform measures must be an accumulation and agreed interpretation of scientific evidence as to what measures are needed. Let me again stress this essential requirement: agreed-upon interpretation of scientific evidence.

In such situations we have frequently sought to handle the problem by parallel action of the concerned nations. However, in seeking to achieve such parallel action we often found difficulty in reaching agreement with respect to the

measures needed, difficulty in timing the measures so they would apply simultaneously and equally to the fishermen of all the nations concerned, or critical delays both in reaching agreement and in applying the measures. These difficulties have often made parallel action somewhat less than adequate for handling serious conservation problems.

To meet these problems we have over the years developed the current type of international fishery commission. At present we have nine of these Commissions (counting the prospective Tortugas Commission). The Commissions have the following principal characteristics: a) their objective is conservation to achieve the maximum sustainable yield; b) the conclusions or decisions regarding conservation measures are to be based on scientific evidence; c) their coverage is confined to one or two related species or to one region, thus simplifying the task to be handled; d) they maintain close liaison with the public through the Commissioners, most of whom are appointed from the area of the Commission's operations, and through advisory committees appointed by each party's Commissioners from the industry and public affected.

The first effective international fishery convention in North America was the Fur Seal Convention of 1911. This might be termed a prototype of the present Convention. It provided for the protection of fur seals but did not provide for joint research, joint consultation or joint management. The next was the Pacific Halibut Convention of 1923. This was the first of the modern type fishery conventions. It provided for a Commission with an international staff responsible for research and management. Since then we have negotiated eight fishery conventions. Of the total four are bilaterals (Halibut, Salmon, Great Lakes and Tortugas), two are trilaterals (Tuna, North Pacific), one is a quadrilateral (renegotiated Fur Seal), and two include numerous countries (the Whaling Convention 15 countries, and the International Commission for the Northwest Atlantic Fisheries 12).

The organization of the several commissions is similar. On each Commission the United States is represented by from one to four Commissioners appointed by the President with one Commissioner coming from the Federal Government and the others from the concerned public. The function of the United States Section is to carry out United States obligations under the Convention within terms of reference provided by the Convention. The Advisory Committee appointed by the United States Section, composed of representatives of the affected fishermen, boat owners, etc., serves a very important function. Members of this Committee are able to keep the United States Commissioners advised of the various problems and activities of the United States industry affected by the Commission and of the practical effects of any measures considered by the Commission. On the other hand, the Advisory Committee also helps keep the concerned United States public informed about the work of the Commission and the reasons for the actions it takes. Thus it has been possible to maintain strong public support for the fishery commissions, and to develop understanding and appreciation of the conservation problems and public support for the often severe and onerous measures required to meet these problems.

The staffs of the various Commissions are of two distinct types, each developed to meet a particular situation. One type involves a single international administrative and research staff which, subject to the supervision of the Commission, is responsible for planning and carrying out the research program of the Commission and for determining what conservation measures are needed. Halibut, Salmon and Tuna are of this type. This form of organization is

particularly effective in concentrating attention on the problems facing the Commission: in developing agreement on the research needed, on the interpretation of the results of research, and on the conservation measures required. This type provides close coordination in applying the conservation measures. The second type of organization involves a small administrative and research staff which, in cooperation with the scientific advisers from the parties to the Convention, prepares, plans and coordinates research programs. The research itself is financed and carried out by the individual Governments. The Northwest Atlantic, North Pacific, Whaling, and Fur Seal Commissions are of this type. This form of organization is particularly appropriate where the parties already have established research programs under way covering the problems to be considered, and it is desirable that each party be able to carry on its research at whatever level it so desires without required proportional participation by the other parties.

There is one Commission which is a cross between these two basic types. This is the Great Lakes Fishery Commission where the lamprey control program is financed by contributions from the member Governments to the Commission, and research on other fishery problems of the Great Lakes is coordinated by the Commission but financed and implemented by the Governments.

The work of the various Commissions possibly has provided the most outstanding and dramatic demonstrations of what can be done through scientific management of stocks of fish. The Fur Seal Convention of 1911 stopped the threatened extinction of North Pacific fur seals and has been instrumental in restoring these stocks, particularly on the Pribilof Islands, to levels approximating those required to produce the maximum sustainable yield. The Halibut Convention terminated the decline of the North Pacific halibut stocks, and through extensive research and practical scientific management has restored these stocks to levels approximating those required for the maximum sustainable yield. The Salmon Convention of the Fraser River has made great strides in restoring the once great sockeye runs of this river and progress is continuing in increasing the runs. The Tuna Commission has established a unique record through attacking the problem of overfishing before it has caused damage, and in providing foresight as to the levels at which the stocks should be maintained. The other newer Commissions have already made considerable contributions to the field of conservation, particularly the Northwest Atlantic Commission which has pioneered the effective application of minimum mesh sizes in maintaining maximum productivity of haddock stocks. Taken all together, the experience we have developed in these Commissions provided much of the basis for the recommendations which the United States Government made to the 1955 Rome Conference on the Conservation of the Living Resources of the Sea, to the International Law Commission, and to the 1958 Geneva Conference on the Law of the Sea, which recommendations have to a large extent been incorporated in the fishery convention negotiated at the latter Conference.

It was mentioned earlier that the United States and Cuba have recently negotiated the Tortugas Shrimp Convention. You will likely be interested in the present status of that Convention, and what developments can be anticipated in the near future.

The Convention has been signed and ratified by the two Parties, and we are now awaiting appointment by the two Governments of Commissioners to represent them on the Commission. Until this has taken place no further action can be taken to implement the Convention. The Commissioners will have responsi-

bility for appointment of their Advisory Committees, determination of the organization, method of operation, staffs, and program of the Commission. Their primary responsibility will be to plan and implement programs of research which will develop the scientific information necessary to determine the conservation measures needed to achieve the maximum sustainable productivity of the Tortugas shrimp stocks of common concern to the United States and Cuba. Other Federal, State and University agencies now have under way in the Gulf area extensive programs, covering research and oceanography on shrimp and other species. Much of this work will contribute to the solution of the shrimp problem of the Tortugas. The Commission will be concerned primarily with work directed specifically to the Tortugas rather than Gulf-wide problems. It will be the responsibility of the Commission to determine how it should fit its organization and operations into this picture so as most expeditiously and effectively to achieve the specific objectives of the Tortugas Shrimp Convention.

Fish and Feed in the Sixties

WAYNE M. WALLER
H. J. Baker & Bro., Inc., New York, N. Y.

IT IS AGAIN my pleasure and privilege to have your attention. My last appearance as a speaker before this distinguished group was on November 17th, 1952 and for the sake of continuity I want to repeat a statement and forecast I made at that time.

"In almost every field of science, engineering and industry, research and developmental activity is at a high pitch. As the findings of the various groups are made known to each other, the effects are going to be far reaching and they will be abrupt, because we have an economy that is conditioned for, and responsive to new products or methods. Because of this ferment in the scientific world, it is important that every manufacturer be kept alerted to the trends and that he be actively planning to adjust to their results."

"Competition from synthetics is very real and tends to lower the relative market prices of menhaden oil, meal and solubles. It is, therefore, highly important that this industry continue to increase its degree of quality control so its products will be less vulnerable to substitutes."

TABLE 1

ESTIMATED U. S. A. BROILER CHICKEN PRODUCTION
1951 — Versus 1958
In Number of Birds

1951	1958	Increase	% of Increase
791,878,000	1,659,636,000	867,758,000	109.58%

My message today is along the same vein as I have been advising fishery feed products manufacturers for the past ten years. Raise the quality and lower the price.

The fish reduction industry has made substantial progress in cost cutting. The development of the power blocks, more complete solubles recovery and refrigerated raw boxes and vessels have made important contributions toward

increased efficiency but these have been borrowed techniques developed by other industries. The fish meal and solubles industry has not and is not spending enough time, talent and money on improved products. The top management of the industry has been about 90 per cent production minded and has neglected product development and marketing.

The following statistics will show the basis for these conclusions. It is realized that figures can conceal as well as reveal, and if the wrong conclusions have been drawn the author would be happy to know about it for these conclusions are somewhat alarming.

The broiler chicken industry is the largest user of fishery feed products in the U.S.A. Between 1951 and 1958 this industry more than doubled its production (Table 1). During the same time the consumption of fish meal and fish solubles in the U.S.A. was increased by only about 5 per cent (Tables 2-4).

TABLE 2
U. S. A. Total Supplies
1951 - 1958
(tons 2,000 lbs.)

Year	USA Production	Imports	Total Supply	Average Use Per Day
Fish Meal				
1951	209,756	128,479	338,235	927
1952	221,403	203,539	424,942	1164
1953	238,851	131,473	370,324	1015
1954	256,967	145,777	402,744	1103
1955	264,502	98,000	362,502	993
1956	295,793	91,400	387,193	1061
1957	262,463	81,200	343,663	942
1958	235,445	103,352*	338,797	928
Fish Solubles & Homogenized Condensed Fish				
1951	50,364	4,000*	54,364	149
1952	70,482	4,000*	74,482	204
1953	81,494	4,000*	85,494	234
1954	115,029	4,000*	119,029	326
1955	110,889	4,000*	114,889	315
1956	128,850	4,000*	132,850	364
1957	122,300	8,000*	130,300	357
1958	130,000*	10,000*	140,000	384

*Estimated

These two facts have been interpreted to mean that the fishery feed fortifiers have not maintained their position in the market, and looking backward it is easy to understand why the marketing practices have undergone such violent changes. In view of the high esteem in which fish meal and fish solubles are held in nutritional circles, why should these products be losing favor? Apparently it is because of the displacement or sparing effects of such items as synthetic methionine, antibiotics, vitamin B12 supplements, fermentation products, 50 per cent protein soya bean meal, poultry meat meal and feather meal. One should not expect to obtain large increases in efficiency when adding fish meal or condensed fish solubles on top of all these ingredients. However the selling price of fish meal should be equal to the cost of making a complete ration using these

competing products. Undoubtedly, loss of sales from fish meal and condensed fish solubles are due to some nutritionists' belief that the substitutes are a more definite and dependable source of the nutrients under consideration than fish meal and condensed fish solubles. In the desperate competitive battle for broiler feed business, terrific pressure has been put on the nutritionist to bring down the cost of the feed, and where some compromise in feed performance is permissible, the fishery items seem to be the first to be reduced or taken out. The situation may be compared to one which has recently taken place in the automobile industry. Several years ago Detroit brought out models with engines of very high efficiency, providing they were fed premium priced fuels. For a brief period these engines were popular, but today, the trend is back toward engines that will burn the regular priced gasoline. Obviously the public has indicated that they will sacrifice a little performance and efficiency if it will permit them to use a fuel of lower cost.

TABLE 3

COMBINED APPARENT DAILY USE OF ALL THREE PRODUCTS

Year	Tons Per Day
1951	1076
1952	1368
1953	1249
1954	1429
1955	1308
1956	1425
1957	1299
1958	1312

TABLE 4

COMPARISON OF AVERAGE DAILY USE FOR THE TWO FOUR YEAR PERIODS

	1951-1954	1955-1958	% of change
Meal	1053	981	—7%
Solubles & H.C.F.	228	355	+55%
Combined Total	1281	1336	+4.3%

Looking back on the past ten years it is clearly obvious now that the fishery feed products have been under gradual but increasing pressure. As the impact of the replacement items commenced to take effect, markets were at times sluggish, the real causes were not generally understood and as the development was so gradual it was most difficult to impress the industry with the true seriousness of what was happening. The U. S. A. has historically needed to import about one fourth of its fish meal requirements and in the early stages of this market contraction the only apparent effect was a gradual reduction in the tonnage of imported fish meal. The market was still broad enough to absorb the domestic production at prices generally satisfactory to the producer. When the industry finally realized that something was wrong, many of them came to the quick conclusion that all they needed to do was change their marketing technique. They took the standpoint that there was nothing wrong with the product, and when they studied the economic outlook they were encouraged by the rapidly expanding broiler chicken industry. As a result there was a rush to set

up direct selling methods, build warehouses to permit year round delivery, and enter into contracts for year round delivery at a fixed price. The storage for round the clock delivery was an excellent and long over-due service, but the rest of the marketing technique only postponed the day of judgment. It did not even approach a solution to the economic problem. No amount of sales promotion or continuous propaganda of scarcity will create a market. If you don't believe so, go out and try to sell a car load of buggy whips. The golden age of the unidentified growth factor is over. We are going to have to come up with some new models.

Based on the assumption that there exists an eager and unlimited market, most fishery feed products manufacturers are today oriented about 90 per cent toward production. Production by itself is futile if the products cannot be sold at a profit. Remember the real customer is the man who uses the feed. The feed manufacturer is only your intermediary. Manufacturers of fishery feed fortifiers need more customer orientation. We must not let the romance of the sea make us forget that the end products must fit into the economy of the land. Customer orientation requires that management be closely in touch with the customer's viewpoint. Briefly he should try to get his entire organization oriented in the direction of better customer service and the production of improved products. Each manufacturer should conduct on his own or subscribe to market research that will give him a basis for estimating the kind and quantity of products that will be in demand. He needs this kind of information on a regional, national and international basis. He should have his 1962 model on the drawing board today and have a reasonably accurate idea of the product he expects to manufacture in 1965.

A broiler ration may contain as many as thirty ingredients. The feed manufacturer sets up quality standards on each ingredient. Working as a group the nutrition council of AFMA has developed a large number of standards. The important consideration, insofar as the feed buyer is concerned, is that manufacturers of ingredients cooperate in trying to produce feed ingredients of the quality required for efficient results. Failure to do so will certainly strongly favor the use of substitute products.

I have asked several leading nutritionists to describe the fish meal they would like to be working with five years from today and here are their answers.

1. "We would not expect anything spectacular to be accomplished but we are going to insist upon uniformity of protein level, a uniform fat level, the fat must be stabilized, the moisture level must be consistent and there must not be any scorched or burned particles. Briefly we want uniformity and we believe that economics will enforce these standards."
2. "I would like to be able to consistently obtain a fish meal of 65 per cent protein, 8 per cent fat and 8 per cent moisture. I think more attention should be paid to processing methods so as to reduce or eliminate protein damage due to over heating. I am not yet decided but believe that I will probably have a preference for a full meal. We want to increase feed efficiency if possible and obviously it would help if we would reduce the moisture in our products. This explains my attraction to a full meal. If it will give me the same boost as the wet solubles at a comparable cost, it will be an improvement."
3. "It would make very little difference to us whether the protein was 60 or 65 per cent. The most important thing we believe is uniformity. By this we mean uniformity of protein, fat and moisture. Uniform high biological

TABLE 5

Estimated 1959 Potential U.S.A. Market for Fish Meal—Solubles & Condensed Fish in Poultry & Swine Feeds Based on Recommended Levels in the Most Essential Rations

Poultry	No. of Birds	Kind & Amount of* Feed Per Bird		Total Tons of Feed	Levels of Fish Products Meal	Sols	Tons of Fish Product Needed Meal	Solubles
Farm Chickens	457,900,000	Starter Ration	2.5 lbs	572,375	3%	2%	17,171	11,448
Broiler Chickens	1,863,000,000	Broiler Ration	8.3 lbs	7,731,450	5%	2%	386,572	154,629
Breeding Flock	27,000,000	Breeder Ration	74 lbs[1]	999,000	5%	2%	49,950	19,980
Turkeys	82,000,000	Starter Ration	8 lbs	328,000	5%	2%	16,400	6,560
Turkeys	82,000,000	Growing Ration	21 lbs	861,000	2%	2%	17,220	17,220
Turkey Breeding Flock	3,565,000	Breeder Ration	47 lbs[1]	83,777		3%	4,189	2,513
Other Poultry							800	400
				Total potential for poultry			492,295	212,750
Swine								
Pigs	102,129,000	Starter	60 lbs	3,063,740	3%	2%	91,912	61,274
Brood Sows	14,800,000	Supplement	45 lbs	333,000	2%	2%	6,660	6,660
				Total potential for swine			98,572	67,934
				Combined Poultry & Swine			590,874	280,684

* Adjusted for mortality & culling

1 Breeder ration only fed during hatching season

value or amino acid content is most desirable but I have no suggestions as to how it could be achieved. Probably it would be worth while for the industry to develop more knowledge of improved drying methods. It would be interesting to learn the biological value of fish meal produced by a freeze dry method. I know it would be impractical and too expensive but it might reveal interesting information. Theoretically a full meal should be better than an ordinary fish meal but in actual practice it would depend upon the method by which it was produced."

If you asked a dozen more authorities the answer would probably be in the same orbit. Uniformity, higher protein, lower fat, no scorching, higher average biological values and maybe a full meal. Briefly those are the objectives that are being set up by the customer and we should be busily orienting ourselves to give him what he wants.

I do not want to leave you with the impression that I am pessimistic about the long range outlook for fishery feed products. Properly processed they are the most efficient products known for their purposes. By 1975 it is estimated that there will be 54 million more people living in the U. S. A. This points to the need for a one-third increase in livestock and poultry production in the next 15 years. We have a tremendous market potential. If all the poultry and swine rations in the U. S. A. were now fortified at the minimum recommended levels, the annual requirements would be about 590,000 tons of fish meal and 280,000 tons of fish solubles (Table 5). Annual consumption today is only about half of this amount; therefore we are a long way from saturating our market. Basically all we need to do is increase our efficiency and average biological values or, to put it another way, simply raise the quality and lower the price.

Sport Fisherman - Commercial Fisherman Relations

David H. Hart

D. H. Hart Inc., Cape May, New Jersey

Although this paper is listed in your program as "Sport Fisherman-Commercial Fisherman Relations," I think probably a more descriptive title would be "The New Look in Sportsmen-Commercial Fishermen Relations."

For more years than anyone cares to remember, the legislative halls of every coastal State and the Great Lakes have been shaken to the rafters with arguments designed to manage our fishery resources. Unfortunately, most of these arguments were slanted to whichever side was presenting them, and in every case conservation came in second best. Both sides won an occasional scrimmage, but time has proven that the conservation war was being lost.

Proof of this might easily be found if anyone took the time to check the laws of several states in regards to any one species. Being from New Jersey and, therefore, more familiar with its problems, I would like to describe how we managed the striped bass or rockfish.

This is a species of fish that ranges the Atlantic Coast from Florida to the St. Lawrence River. It is a beautiful game fish with wonderful fighting qualities. Also an excellent food fish, so naturally it is sought after by both sport and commercial interests.

Each year, prior to 1953, sportsmen descended upon the State House in Trenton with a host of bills designed to regulate the taking of these fish. Com-

mercial men countered with others, and dependant upon the pressure generated, and the mood of the legislators, anything could, and did happen. When netting was permitted, the butchers, the bakers, and the police and firemen turned commercial fishermen to get in on the gold rush. When netting was restricted, the real commercial fisherman had to sweat it out and continue the fight.

Most of the laws passed were the result of pressure groups with guess work as the principal argument, and while they were advanced as conservation measures, they were often the opposite. Here is an example. In the spring, striped bass in their northward migration occur in New Jersey coastal waters at the same time as shad. One regulation permitted the use of a staked gill net 25 fathoms long, with a minimum mesh of 5 inches stretched for the taking of striped bass only. Another regulation, at the same time, permitted the use of a staked gill net 30 fathoms long, and a minimum of 5 inches stretched mesh for the taking of shad only. These nets were fished at the same time, and in the same waters, and it is quite obvious that if a shad, by mistake, was caught in the wrong net he had to be returned to the water. Also, if a striped bass became gilled in a shad net he could not be retained.

The commercial men knew the law, and so did the sportsmen. The fish could not read, and so was blamed for all the trouble. However, all of this was finally corrected when in 1953, after years of wrangling, the striped bass was made a hook and line fish only. This solved two problems. It satisfied the crusader who fanatically fought for this type legislation, and it also solved a serious social and political problem. It also came very close to destroying the future of the fishery scientist and biologist in New Jersey because this law was passed against the advice and strenuous objections of the best fishery biologist in the country on this specie. It was felt by many that if you do not take the advice of the doctor, you are wasting his time, and yours too.

I at the time was so concerned, that I sponsored a resolution at the following meeting of the Atlantic States Marine Fisheries Commission in New York, urging the member States in the future to give more consideration to the advice of fishery scientists and biologists in managing their fisheries. This served notice that the managing of our fisheries had to be based on sound scientific fact if we were to practice real conservation.

Sportsmen whose questions could not be answered to their satisfaction in the past are now supporting research programs in the hope that they will lead to better utilization of the resources. Meetings have been held jointly with commercial fishermen, and instead of mortal combat, all were surprised to find areas of agreement, and many common interests. A very good example is the problem of the menhaden fisherman. The success of this fishery depends upon their being permitted to fish in close to shore. Many times during a season, the heaviest concentrations of these valuable fish are almost into the surf. The sight of this activity so close to shore has been the source of many complaints. The industry has been plagued over the years by well intentioned, but ill informed persons whose sincerity could not be questioned, but who had no knowledge whatever of the facts. The Cape May County Gazette, a weekly newspaper in Cape May County, New Jersey, reprinted in their "Auld Lang Syne" column on September 3, 1959, an article printed 75 years ago in 1874, and I quote, "Blue fishing has never been as poor as it has been in the past five years, and unless something is done to suppress the activity of the Menhaden Steamers, we can look for very little improvement." End quote. This same article could have been printed just a few years ago when it was still believed by many that menhaden

fishermen were catching large quantities of food fish, when in reality they do not catch enough to feed their crews. After many meetings with sportsmen's groups, municipal officials, and others interested in conservation, it is now known by the majority that menhaden fishing is not detrimental to recreational fishing.

When the program was announced of the proposed plan to study the estuarine area of our Atlantic and Gulf Coasts, the menhaden people were the first to favor this worthy cause. The marsh lands are of the greatest importance to the menhaden industry, because all menhaden spend a large part of their first year in this area. The future catches depend upon the successful rearing of the juveniles, and it is natural that menhaden producers are interested in the wet lands.

The wet lands have a multiple use. They are used as a nursery area for many species of food fish, shell fish, water fowl, and the hunter. Here then is a common area of mutual benefit to both sport and commercial interest. Save the wet lands. Many thousands of acres of marsh land adjacent to menhaden plant installations have been purchased by the plant owners, and recreational privileges are granted to water fowl hunters and fishermen. This is concrete evidence of a new look.

Since the Saltonstall-Kennedy program came into being, millions of dollars are being spent in research. Most of the states have expanded their programs, and are cooperating with the Bureau of Commercial Fisheries to avoid duplications of effort. More work is being done by fishery scientists today than at any time in the history of the industry. One thing has become crystal clear. We have not in the past properly managed our fishery resources. In the future we should not pass a law unless it is supported by sound scientific fact based on research. We should not press our researchers for premature statements based on limited research, but should wait until they are able to make suggestions that are scientifically sound.

It is a must that sportsmen follow the example expressed by Hal Lyman and Dick Stroud at the recent meeting of the Atlantic States Marine Fisheries Commission at the Governor Clinton Hotel in New York. They suggested, among other things, that both groups meet more often, and try to reconcile their differences. Further, to support a scientific research program that will assure proper exploitation of our fishery resources, and through proper management there will be enough for all.

Potential Markets for Products of the Industrial Fisheries

JOHN A. HOLSTON
Bureau of Commercial Fisheries, Washington, D.C.

THE INDUSTRIAL fisheries form a unique and romantic segment of the fishing industry. Time was, when the industrial fisheries sailed comfortably along with assured markets for each of its products. Today, technological improvements in competitive products such as soybean meal, synthesis of cheap vitamins and other nutrients, development of totally new products such as the water-based paints, all have contributed to a gradual wearing-away of these previously assured markets. Today, this multi-million dollar industry is largely reduced to dependence on single major outlets for its meal and its oil. The instability of even these markets is pointed up by the increasing use of fish meal as "nutritive insurance." The feed formulator includes fish meal in his rations not because

of its known essentiality but because other cheaper products have not as yet demonstrated the capacity to yield as firm a nutritional foundation for chick growth as does fish meal.

Obviously, such an undesirable situation cannot be allowed to continue. The Bureau of Commercial Fisheries, in cooperation with the industry and the Industrial Products Division of the National Fisheries Institute, undertook research investigations to remedy the market outlook of the fishery. The research goals were three in number: (1) the accumulation of as much knowledge as possible on the chemical structure and chemical and nutritional properties of the industry's products (2) the diversification of market outlets to render the industry relatively independent of any one market and (3) having established new outlets, to so improve their products through continuous research as to maintain them on a par with competitors. These have been the guidelines used.

In attaining these goals, some success has been made, notably in demonstrating the nutritional value and total market value of fish meal. Our technologists have shown that when chicks are raised under normal stress conditions in pens, the inclusion of fish meal in the ration protects the chick and permits markedly better growth than does an all-vegetable protein ration. Some success has also been obtained, in exploring for new uses for fish oils. Last year, successful research results were reported with respect to use of fish oils in ore flotation and in the preparation of leather.

The pressure of the industry's need for immediate assistance prevented us from giving too much attention to the development of new markets for its products. It is felt that this objective of the research program can be no longer delayed.

Fortunately, our recent research findings, with respect to the cholesterol-depressant activity of fish body-oils have indicated a possible outlet for the oils. This is in the form of an encapsulated, concentrated, dietary supplement designed to balance the U. S. citizens' excessive intake of "hard" fats with its attendant hypercholesteremia, atheroma and other accompanying ills. Each of us here probably would evidence some degree of elevation of his blood-cholesterol levels. It is known that practically all U. S. citizens over the age of twenty-five have atheroma, waxy deposits of calcified cholesterol, in their vascular systems.

Two years ago, under contract with the Bureau, the Hormel Institute of the University of Minnesota undertook to determine whether cholesterol level reduction might be achieved by feeding fish oil and fish oil fatty acid fractions to hypercholesteremic animals. By means of special diets, the cholesterol levels of the blood of rats and miniature pigs were made to rise to approximately 300 per cent above normal. The animals were then randomly separated into a total of four different groups. One group, the control, was continued on a diet containing 10 per cent tallow or "hard" fat completely saturated or, at best, one point of unsaturation. Group two was fed a diet containing 7 per cent tallow plus 3 per cent of purified, standardized linoleate, the active agent in corn oil, safflower oil and other vegetable oils. Linoleic acid contains two points of chemical bond unsaturation. Groups three and four were fed a diet containing 7 per cent tallow and 3 per cent, respectively, of menhaden oil and tuna oil. These oils contained fatty acids varying in unsaturation from one to six points.

It is interesting to note three things. One, the cholesterol reducing activity of the fish oils was immediately observable whereas, in the case of corn oil's linoleate, a two week delay was observed. Second, the total over-all reduction

in cholesterol levels was significantly greater for the fish oils than for the linoleate. Whereas the corn oil acid reduced the cholesterol level to a high "safe" level, the fish oils both reduced the level to a point only slightly above the "normal." Third, whereas the corn oil agent was tested in its purified, standardized and concentrated state, the fish oils were tested largely as found in nature. The oils were therefore at a marked disadvantage. Nevertheless, they were much more effective than was the corn oil.

These findings led naturally to the assumption that the fish oils might (1) be more effective if concentrated and (2) show that cholesterol-depressant activity is a function of increasing chemical unsaturation of the fatty acid molecule. Further tests were made, feeding hypercholesteremic animals a diet containing 7 per cent of hard fats and 3 per cent each of certain fractions of fish oils. These fractions, as indicated by their I.V. (Iodine Value), were characterized by increasing unsaturation. These results conclusively demonstrated that the cholesterol reduction activity was proportional to the degree of unsaturation of the oil.

Three immediate benefits flow from these observations. The first is that highly unsaturated fish oil fractions should be the oils of choice in future clinical treatment of hypercholesteremia. The second is that feeding of such concentrates should reduce the caloric intake, itself a problem in terms of possible weight gain by the patient during treatment. Effective dosages of corn oil have been from 2 to 3 ounces daily whereas the dosage of a fish oil concentrate may well be in the ranges of from one ninth to one third of an ounce. Thirdly, such concentrates may conceivably be encapsulated and taken regularly like our ubiquitous aspirins and our tranquilizers. I must here mention that our results have not established high cholesterol as the cause of atherosclerosis nor have we cured any case of atherosclerosis.

It is the Bureau's hope that these findings will open a new market and possibly a new era for the fish body oil industry.

What are the chances for the development of alternative markets for products derived from the flesh of industrial fish? The Bureau of Commercial Fisheries considers the production of fish flour to be the most promising alternative outlet. Consumer acceptance tests have been successfully conducted in Chile, Thailand, Indonesia, Mexico and other countries. Production, on a day-to-day but rather erratic basis, is under way in South Africa, Canada, Great Britain, France, India, Germany, Russia, Morocco and the United States. All of this interest has been generated through the recent growing awareness of the world's ever more critical need for protein.

Protein malnutrition quite likely is the most important single nutritional deficiency in the world today. It is a problem both in the underdeveloped *and* the developed countries. The Bureau considers the development and production of a stable, nutritious fish-protein food supplement—fish flour, if you will—to be the next logical development in the industrial fisheries. The evolution of the industrial fisheries from producers of fertilizers, indirectly furnishing food for man, to producers of poultry feed ingredients, directly feeding the food of man, was justified because of the high nutritional value of the industrial fish. The next logical step, that of directly feeding man, is now long overdue.

There appear to be five potential markets for fish flour where cost of production is not presently a critical consideration. These are: (1) the underdeveloped countries, (2) the rations of the military, (3) children's diets, (4) geriatric (oldsters') diets, and (5) special medical diets. Such a stable, preserved product,

containing from 65-70 per cent or from 95-98 per cent animal protein depending upon processing method, B-vitamins, calcium and phosphorous, would help to give the protein-deficient child the 10 to 15 grams (about one third to one half ounce) so necessary to keep him in nitrogen balance. This would be comparable to the 30 or 40 grams of skim-milk powder necessary to sustain him for the day. It would permit easy incorporation within the field ration of the soldier and of the airman on the fringes of space of the most nutritious and most concentrated form of protein known to man.

In general, fish flour is ideally suited for the diet of children. Its biologically complete, easily digestible protein is excellently adapted to their still immature digestive processes. Its incorporation in breads, cakes, cereals, pastries, etc. would permit the parent to give her child his daily protein requirement in a most pleasing form and would eliminate the fear of his "spoiling his appetite for dinner." Four "toll-house" cookies containing three per cent of fish flour by weight would supply approximately two-fifths of his daily protein requirement.

Fish flour is potentially an excellent addition to the geriatric diet. Believe it or not, many of our elder citizens are suffering from a sub-clinical protein deficiency. They refuse or are unable to chew the tougher meat products and content themselves with a badly unbalanced diet of potatoes, cereals, cakes. bread or eggs. Fish flour contains little or none of the sodium or carbohydrate trouble-makers for old folks. Inclusion of fish flour in food products utilized by elderly persons would do much to help their nutritional well-being.

In general, fish flour is applicable to any medical diet which is designed to yield (1) biologically valuable trace minerals, (2) high levels of B-vitamins, (3) reduction of sodium intake, (4) reduction in fat and carbohydrate intake as well as (5) high levels of easily digestible, biologically complete, readily available protein.

Rough estimates as to costs indicate that fish flour, when judged on a per-pound-of-protein basis is even now cheaper than dry milk solids and closely competitive with soyflour. The Bureau feels that an adequate study of the engineering requirements and of nutritional standardization of fish flour would reduce costs further, open a potentially limitless market in the American food manufacturing business and possibly make available to the underdeveloped countries a gift more valuable than all of our contributions to date.

Continuous Distribution of Menhaden Along the South Atlantic and Gulf Coasts of the United States

JOHN W. REINTJES
Bureau of Commercial Fisheries
Beaufort, North Carolina

Introduction

THE MENHADEN purse-seine fishery of the Atlantic and Gulf Coasts of the United States depends almost exclusively upon two distinct and geographically separated species: the Atlantic menhaden *(Brevoortia tyrannus)* and the Gulf menhaden *(B. patronus)*. The Atlantic menhaden ranges from Nova Scotia to the central east coast of Florida, while the Gulf menhaden generally occurs from

the central west coast of Florida to the Mexican border. Landings of Atlantic menhaden have averaged well over one billion pounds annually for the past five years, while landings of the Gulf menhaden have averaged nearly a half a billion pounds annually during the same period.

The fishing grounds and the location of plants for processing the catch are determined by the seasonal occurrence and abundance of the fish. Annual, seasonal, and geographical fluctuations in fish availability and abundance have troubled the menhaden industry from its beginning. Thus the fundamental questions of this industry are these: (1) What is the nature and the extent of the resource? (2) What are the causes of fluctuations in the catch? and (3) Are fluctuations in the catch predictable?

The elucidation of the above questions requires a thorough knowledge of the species which constitute the resource, their distribution in time and space, and the extent of mixing between them. In the present discussion only the first question will be considered and this will be further confined to our recent work and findings concerning the species which occur over a relatively short area of the range, *viz.*, the menhaden off the Florida peninsula.

Background

In addition to the Atlantic and Gulf menhaden, two other menhaden species have been reported from North American waters;[1] these include the yellowfin menhaden *(Brevoortia smithi)* and the fine-scaled Gulf menhaden *(B. gunteri)*.

The Atlantic and Gulf menhaden are very similar; both have large scales arranged in regular rows, numerous black pigment spots are present along the sides of the body, prominent ridges occur on the opercle or upper part of the cheek, and head and body are elongated. As adults the Atlantic and Gulf menhaden school in open coastal waters and both apparently spawn in the ocean.

The yellowfin menhaden and the fine-scaled Gulf menhaden constitute a second pair of closely related species. They have fine scales which form no discernible pattern, there are no secondary black pigment spots on the sides of the body, opercular ridges are very faint or absent, and the head and body are shortened. As adults the yellowfin menhaden and fine-scaled Gulf menhaden aggregate in loose, scattered schools in tidal embayments and estuaries. Both yellowfin and fine-scaled Gulf menhadens apparently spawn in inland tidal waters.

Each pair of similar species *(Brevoortia tyrannus-B. patronus* and *B. smithi-B. gunteri)* also have other structural and biological features in common including: shape of the fins and scales, body texture and color, maturation of gonads, and behavior.

Until recently, our knowledge of the distributions of the foregoing species was based entirely on Hildebrand (1948) and may be summarized as follows:

(1) Atlantic menhaden *(Brevoortia tyrannus)*—Nova Scotia to Daytona Beach, Fla.

(2) Gulf menhaden *(Brevoortia patronus)*—Tampa, Fla. to the Mexican border

(3) Yellowfin menhaden *(Brevoortia smithi)*—Cape Lookout, N. C. to Cape Canaveral, Fla.

---

[1] A fifth species, *B. brevicaudata*, was described by Goode (1878) on the basis of a single collection from Noank, Connecticut; however, this species has not been reported since.

(4) Fine-scaled Gulf menhaden *(Brevoortia gunteri)*—Grand Isle, La. to the Mexican border

Hildebrand (1948) stated that menhaden did not occur off southern Florida and substantiated this belief by observations from the Keys made by himself, Isaac Ginsburg, and Charles M. Breder, Jr. Hildebrand's conclusions, that separated and isolated species occurred in the Gulf of Mexico and along the East Coast of the United States, was not challenged by any reported occurrence of menhaden off the southern peninsula of Florida for nearly a decade. It was not until Suttkus (1958) recorded the occurrence of the yellowfin menhaden from Placida (between Sarasota and Fort Myers on the west coast of Florida) that the hypothesis of a complete separation of menhaden from the Atlantic and Gulf Coasts was subject to doubt. Especially noteworthy was the claim by Suttkus (1958) that the occurrence of yellowfin menhaden in the Gulf of Mexico was known to Hildebrand (personal communication from Dr. Henry B. Bigelow).

It is of further interest to note that small quantities of menhaden were recorded in the commercial landings of southern Florida for 1957. Rosen and Ellis (1958) reported the following: Dade County—184 pounds; Monroe County—222 pounds; and Collier County—96 pounds. These three counties compose the southern peninsula of Florida, including the Keys. Although the report did not identify the menhaden by species, nor specify the area of capture, it is known that commercial fishing for fin fishes in this area usually is conducted in close proximity to the ports of landing. Although the quantities of fish caught are not impressive, this report furnishes evidence of a continuous distribution of menhaden around the peninsula of Florida.

The foregoing review pointed out the need for a reconsideration of the identity, distribution, and abundance of menhaden species, with particular reference to the coast of Florida.

Field Studies

Results of our Atlantic Coast menhaden catch-sampling program, conducted over the past five years, showed the presence of yellowfin menhaden in Florida and Georgia waters, both as juveniles in the estuarine nurseries and as adults in the commercial purse-seine catches landed at Fernandina Beach, Florida. Juveniles have been relatively common in haul-seine collections in the area. Adults, on the other hand, were rarely encountered among the commercial purse-seine catches of Atlantic menhaden, although occasional small landings consisting entirely of yellowfin menhaden were reported.

Farther southward, a commercial gill-net fishery on menhaden for bait purposes is conducted in Indian River from Ponce de Leon Inlet to St. Lucie Inlet. The bulk of the catches are made in the central part of the area in the vicinity of Sebastian, Florida. Because of the selectivity of the gear used, the size of fish taken by this fishery is uniformly large, ranging from about 8 to 12 inches, fork length.

Samples of menhaden landings at Sebastian have been obtained at infrequent intervals since 1956. Resulting data have shown that the catch through most of the year was composed principally of yellowfin menhaden. During the late fall and winter, however, Atlantic menhaden frequently appeared in the catches. Most often there were only a few scattered individuals of the latter species present, but occasionally they constituted from 10 to 15 per cent of the landings. It was also found that the field identification of individual fish by species, at

times, was difficult or virtually impossible. The characters which distinguish the individual species are not qualitative and discrete, but consist entirely of a series of quantitative and continuous features such as body and head lengths, scale size, body texture, shape of paired fins, etc. Thus it soon became evident that the recognition of the described species was not a simple matter of applying usual field identification procedures.

Beginning in 1958, a reliable identification of individual specimens was achieved based entirely upon the enumeration of scales and vertebrae. This work also demonstrated the presence of a third species in the area, in addition to the yellowfin menhaden and the Atlantic menhaden. This third species was found to possess characters which were exclusively neither those of the yellowfin nor the Atlantic menhaden. Thus the accurate field identification of North American menhadens on the basis of easily recognized qualitative characteristics became more remote. it should be noted here that the third species encountered along the central Atlantic coast of Florida could be the Gulf menhaden *(Brevoortia patronus),* either of the South American menhaden *(B. pectinata* or *B. aurea),* or a new, unreported species.[2] It is possible, but unlikely, that the unclassifiable fish encountered are the result of hybridization. However, because sufficient comparative material is not yet in hand, and because of an overlap of characters, a decision concerning the identity of this third species has not been reached. Suffice it to say that collections of menhaden from the Gulf of Mexico and South America are being obtained, and efforts made to solve as quickly as possible the species problem which exists in the tropical waters of North America.

The foregoing findings indicated that menhaden distribution along the Atlantic Coast of the United States does not terminate in central Florida as was thought, but continues farther southward. In an attempt to learn more about the identity and seasonal occurrence of menhaden in Florida waters, two survey trips were made to the area in 1959. It was learned that there is little or no utilization of menhaden in areas south of Sebastian. The blue crab fishery, for example, the principal market for menhaden bait in the Indian River area, is of minor importance from Palm Beach County southward. Furthermore, there is little fishing with gears capable of catching menhaden within the inland coastal waters south of Indian River. Although menhaden occasionally occur in cast-net, otter or shrimp-trawl, and haul-seine catches—gill or trammel nets which are fished in the oceanic waters of southern Florida are the only gears employed which are capable of catching menhaden in any quantity. At present there is a winter fishery (December through March) for king and Spanish mackerel *(Scomberomorus cavalla* and *S. maculatus)* in the coastal waters from Palm Beach to Fort Myers, and on the first survey trip in early January 1959, interviews with twenty mackerel fishermen disclosed the following information:

(1) Menhaden or "fatbacks" were known to all but two of the fishermen, either by name or were recognized on being shown fresh specimens.

(2) Menhaden frequently were encountered in the vicinity of king and Spanish mackerel schools and, in general, the fish were believed to follow somewhat the same seasonal movements as the mackerel. On occasions menhaden had been so numerous as to disrupt mackerel fishing, and

[2]Two small menhaden specimens were received by the Museum of Comparative Zoology, Harvard University, in 1872 from Poey, the Cuban ichthyologist. The locality was recorded as Cuba, and the tentative identification was given as *B. tyrannus,* the Atlantic menhaden.

their presence among the mackerel was looked upon as a nuisance.

(3) Localities of greatest abundance of menhaden were reported to be (a) from Miami to the northern end of Key Largo, (b) in the vicinity of Shark and Lostman's Rivers, and (c) off Cape Romano in the vicinity of the Ten Thousand Islands. Localities of least abundance were along the Keys, both on the Atlantic side and in Florida Bay on the Gulf of Mexico.

(4) Because no market exists for menhaden in this region, no attempt has been made to exploit the fish.

No specimens were obtained during the initial trip to the area, since mackerel fishing was temporarily suspended due to a northeast storm. On the second trip to the area in mid-February 1959, nine menhaden specimens were obtained from a gill-net catch taken in the vicinity of Cape Romano. Of these, eight were yellowfin menhaden and one was provisionally identified as the Gulf menhaden.

In summary, the results of field observations and preliminary studies have shown that the menhaden stocks of the Atlantic and Gulf Coasts are not isolated and separated from each other, but are distributed continuously around the Florida peninsula. It is further suggested that commercial quantities of menhaden may be available at certain times of the year in the tropical waters of North America.

While these preliminary findings are incomplete and inconclusive, they are of significance to the scientific studies which are now being conducted on the Atlantic Coast and will be of greater importance when the work is expanded in the Gulf of Mexico. Continuing information on these matters will be of considerable help in solving several of the most perplexing problems which still confront us. These include: (1) the habits and places of occurrence of the main body of adult Atlantic menhaden during several of the winter months, (2) the existence and whereabouts of the older and larger Gulf menhaden, and (3) the size of the yellowfin menhaden resource. I do not mean to infer that these stocks of fish are in the lower Gulf of Mexico or the Caribbean Sea. However, until more is known of their movements and distribution, any conclusion concerning these stocks is speculative.

LITERATURE CITED

Goode, George Brown

1878. A revision of the American species of the genus *Brevoortia,* with a description of new species from the Gulf of Mexico. Proceedings U.S. National Museum, vol. 1, pp. 30-42.

Hildebrand, Samuel F.

1948. A review of the American menhaden, genus *Brevoortia,* with a description of a new species. Smithsonian Miscellaneous Collections, vol. 107, No. 18, 39 pp.

Rosen, Albert and Robert W. Ellis

1958. Summary of Florida commercial marine fish landings for 1957. The Marine Laboratory, University of Miami, Report 58-2, 65 pp.

Suttkus, Royal D.

1958. Distribution of menhaden in the Gulf of Mexico. Transactions Twenty-third North American Wildlife Conference, pp. 401-409.

Development of an Air-Bubble Curtain for Catching Maine Sardines [1]

KEITH A. SMITH

Bureau of Commercial Fisheries, Boothbay Harbor, Maine

Abstract

Conventional methods of catching Maine Sardines (small Atlantic herring) rely upon migrations of schools of the fish into shallow-water coves where they can be caught alive with stop seines or weirs (traps). The schools often stop short of or swim past such areas. A system of guiding and driving herring schools from deep to shallow water, using a curtain of air bubbles, has been developed by the U. S. Bureau of Commercial Fisheries. Air-bubble curtain gear consists primarily of (1) an air compressing unit including engine, compressor, air receiver and aftercooler; and (2) an air discharge unit constructed of flexible plastic pipe that is perforated with 1/64-inch holes at 1-foot spacings, and weighted with lead to make it sink. Compressed air at 50 to 80 p.s.i. pressure is discharged through the 1/64-inch holes setting up a "curtain" of small air bubbles rising from the sea bottom to the surface. Herring schools resist passing through the bubble curtain and can be guided along it and driven before it to the shallow-water seining or trapping sites.

[1]This paper is scheduled for early publication in *Commercial Fisheries Review*.

WEDNESDAY—NOVEMBER 11

Chairman—LAWRENCE W. STRASBURGER, *Food Technologist and Consultant, Metairie, Louisiana*

Highlights of the Second F. A. O. World Fishing Boat Congress

L. C. RINGHAVER
Diesel Engine Sales, Inc., St. Augustine, Florida

RECENTLY I ATTENDED the second World Fishing Boat Congress which was held in Rome, Italy. The first World Fishing Boat Congress took place in November of 1953, during the Gulf and Caribbean Fisheries Institute Convention in Miami Beach. At that time, I had the opportunity to present a few remarks pertaining to shrimp trawler production. The outcome of this First Fishing Boat Congress was the book called *Fishing Boats of the World*. This book is based on all the papers that were delivered at this Congress and the experience of all the workers in many parts of the world. A similar book will be published, probably next year, covering all the discussions that took place at the second Congress, held in Rome. This will be the most up to date book on fishing boat development.

The Congress Meeting in Rome took place April 5th through April 10th, 1959. Fifty technical papers were presented of which one was mine. Thirty-five different nations were represented at this meeting; Mexico was represented with one delegate as well as Cuba. The United Kingdom had forty-two. The United States had nineteen and Soviet Russia had four. The Japanese had a good attendance of ten. Nearly three hundred people attended this meeting.

The conference was organized by Jan-Olof Traung, who is the Secretary of the Fishing Boat Congress and has his headquarters in Rome. The theme of this Congress was performance and this was broken down into four subjects:

Tactics, Construction, Sea Behavior and Productivity. One day was allocated to each of these subjects.

The discussion on *tactical methods* was split into sessions on fishing methods and deck arrangement, and command of operations. The authors of these discussions discussed drift-netting, gill net fishing, and trawling, etc.

The subject of *construction* was divided into sessions on scantlings, fish holds, and installation of machinery and cost of construction. There is quite a variance in the standards established in the various foreign countries as to the types of material that can be used for boat construction, and a discussion was held on the use of uniform scantlings or timbers and their standardization. The session on fish holds as well as various freezing methods aroused much interest. As to installation of machinery, no individual engine design was singled out, but there was a general discussion on the types of installations. As to vibration, quite a debate was held on the relative merits on controllable pitch propellers. Also, in this discussion, costs were brought up on the United States

fishing vessels, and it was emphasized that construction costs were much lower in Europe.

Sea Behavior was divided into sessions on propulsion, stability and safety at sea. This discussion was strictly in the hands of the Naval architects. The majority of the people present were Naval architects who stressed their views as to the types on construction for the various fishing vessels. It was also brought to the attention of these architects that they and the fishery technologists should cooperate more closely on such matters as the efficiency, the simplicity and the cost of fishing boats.

Mr. H. C. Hansen, a consulting Naval architect from Seattle, Washington, presided on the session "Safety at Sea," which was an excellent discussion. It emphasized the importance of training fishermen to become good seamen. It seems that throughout the world the fishing industry is faced with low caliber personnel for manning their fishing fleets. Many safety measures were also discussed to prevent the loss of lives and fishing vessels.

Mr. H. I. Chapelle, who is a well known author on fishing boats, gave an interesting talk on fishing boat design. This discussion covered everything pertaining to hull information and the scientific study.

The last day was taken up with *Productivity,* and various boat types were discussed, and at this time I presented my paper on the "Design and Mass Production of Shrimp Trawlers." These are a few excerpts from my paper. "The design of the Florida shrimp trawler is similar to the old Greek sponge boats which were constructed many years ago. In the early part of 1947, we arranged with a group of Naval architects to lay out a trawler on the lines of the Florida shrimp trawler, which would be simple and could be safely handled by a small crew. Its design must be such that it could be standardized. As American trawler crews frequently change from boat to boat, therefore also it must have comfortable accommodations and sea *kindliness.*" In my paper the details on the scantlings that were used in our trawler were given. Our 67 foot shrimp trawler was a perfect example of mass production. This boat affords sheer forward and aft which makes it a very dry vessel. It was necessary when we designed this boat that it should be a sound and profitable vessel at the minimum cost, because the purchaser usually has to borrow 75 per cent of the purchase price to finance it. We know that financing is not as difficult as it was in the past especially when you have a standard design fishing trawler. It has been proven that the shrimp trawler in the United States is more readily financed than any other fishing trawler. The underwriters also play an important part, because if they do not approve of the vessel, the loaning institutions will not be interested in financing.

I had the opportunity to present to the Congress the lines and offsets of our shrimp trawler. The ample sheer at the bow gives it a relatively dry deck and its round bottom makes it good in a head sea.

The following remarks were delivered by Mr. Jan-Olof Traung after I delivered my paper. He stated that according to Professor Lewis, a well known authority, the lighter boat on a given length has a better sea behavior and less stresses in a seaway, and that is the reason why fishermen prefer the wooden type hulls to the steel type hulls which are being built from time to time. The fact that the transom stern gives a good damping is why the head sea performance is said to be excellent. Mr. Traung also stated that the prismatic coefficient of the Diesel Engine Sales boat is very low and that is the reason for good head sea performance. He said that all the scantlings or timbers used were sufficient.

Papers were delivered on the use of outboards on small fishing boats, as there are many of these boats in use throughout the world. There were numerous discussions as to whether an inboard was superior to an outboard on these small fishing craft.

As mentioned before, many Japanese were in attendance. As one knows, the Japanese coastal fishing boats are simple and inexpensive to construct. There are more than 130,000 small, unique fishing craft from one to five tons along the open and sheltered coast of Japan, most of which are operated as small individual enterprises. These boats are built of wide wooden planks without complete frame systems. These boats are called "yamato" type, and they are said to have been developed from the fifteenth century dugout vessel. These boats are used for pole fishing and seining, etc. They are very weak in construction as they have very few planks to give them strength and the length is generally limited to about fifty feet.

Since World War II the Japanese have gone in for many refrigerated factory ships. The first factory ships were remodeled from wartime standard ships. Recently, they have built new refrigerated factory ships, and now they have over fourteen. The Japanese are quick to adapt themselves to the changes in the fishing industry, and the fact that they have an abundance of labor and low wages are the reasons that they are constantly developing their industry.

In the North Pacific where they do salmon and trout fishing, a refrigerated factory ship will have with it thirty "catcher" boats which average from 50 to 80 gross tons. These "catcher" boats bring the fish to the mother ship where it is processed and canned. This factory ship also provides the gear, fuel, etc. to the smaller boats.

Professor A. Takagi, Professor of Naval Architects at the University of Tokyo, reviewed the Japanese work, which is the development of two large fishing vessels for nuclear or atomic propulsion to be completed by 1975. The possibility of an atomic preservation of fish, which might make freezing unnecessary, was mentioned.

It was stressed that since 1953 there have been so many new developments in connection with fishing vessels, that more fishing vessels today are being built with transom sterns and that more and more naval architects are being employed in design and construction. The construction of boats was a very important subject because fishing boats are usually built by traditional methods or according to regulations made by the government and classification societies. Many times it is found that existing construction regulations would make the fishing boats cost much more than the owner could reap in returns.

In view of the changes in boats by 1975, automation will probably make considerable progress. Boats will be designed to operate with smaller crews. The fishing boat of the future might even be airborne with adjustable jets to keep them stationary or at low speed when fishing. Such vessels would fly with their catch direct to consumption centers far inland. The development in the fishing craft design will continually accelerate as long as technical progress goes on.

A great tribute is due to F. A. O. World Fishing Boat Congress and their commendable organization for all the proceedings that took place in Rome, and the fact there was a complete exchange of information from all the specialists related to the fishing boat industry.

Recent Advances In Shrimp Technology

John A. Holston
Bureau of Commercial Fisheries, Washington, D. C.

Abstract

About 90 per cent of the breaded shrimp in the United States is produced under the continuous inspection of the Department of the Interior. Inspectors are stationed in 14 plants producing breaded shrimp. Although final inspection is made on the frozen product, the inspector must check on the quality of the incoming shrimp and other raw materials to insure the proper use of the Grade A label. The freshness of the shrimp is determined organoleptically at the present time. Our technologists are studying the chemical characteristics of shrimp spoilage with hopes of devising simple objective means of evaluating freshness. At present, the Nessler's test and the newly developed Picric Acid Turbidity Test appear promising.

Factors Affecting Yield of Meat From The Blue Crab [1]

C. F. Dunker, D. H. B. Ulmer, Jr., and G. W. Wharton[2]

Summary

Steam-boiling crabs at 212°F. for 15 minutes, in contrast to steaming at 15 pounds per square inch (p.s.i.) (250°F.) for ten minutes, resulted in an increase of crabmeat, such that a monetary savings of over one dollar per barrel (100 lbs.) live crabs can be realized.

One hundred pounds of picked meat will consist of approximately 53 per cent regular white, 25 per cent of backfin lump, and 22 per cent of claw meat.

Chesapeake Bay crabs in Maryland showed highest yields of crabmeat in summer, followed in decreasing order by spring, fall and winter crabs.

When steaming crabs at 15 p.s.i. (250°F.), in general, a ten minute cook produced more picked meat than did either shorter or longer cooks.

Choptank River crabs, mainly male crabs, gave higher yield than did Chesapeake Bay female crabs.

Cooking crabs ten-fifteen minutes at 212°-227°F. resulted in maximum crabmeat yield; but with temperatures of 239°-250°F. maximum yield occurred at five-ten minutes, with marked reduction in yield at fifteen minutes.

Study made of two methods of post-cook handling: namely deback and refrigerate before picking versus whole crabs held at room temperature, showed a tendency for the former method to result in higher yields.

Introduction

If a processor is producing crabmeat of the highest quality, with good storage characteristics, he will surely be interested in any factors which might increase his yield. With this thought in mind, the following research results are pointed out. Yield of picked crabmeat is affected one way or another by such factors

[1]Contribution from the University of Maryland Seafood Processing Laboratory, Crisfield, Maryland. This is a revised version of the paper read at the Institute and was presented at the Fourth Atlantic Fisheries Technological Conference, Halifax, N.S., March 7, 1960.
[2]C. F. Dunker, Director, and D. H. B. Ulmer, Jr., Research Associate of the University of Maryland Seafood Processing Laboratory. G. W. Wharton, Professor and Head, Department of Zoology, University of Maryland.

as: method of cooking, time of year, length of cook, source of crabs, temperature of cook, and post-cook handling methods.

Method of Cooking

A series of twelve plant runs were carried out, comparing steam-boiling against pressure-steaming. In steam-boiling, high pressure steam at 50-60 p.s.i. entered the bottom of an open retort through a spreader, causing the water in the retort to boil turbulently at 212°F. While the crabs were being steam-boiled for fifteen minutes, the water was continuously recharged with sterile water from the steam condensate, and simultaneously the foam and detrita, caused by boiling the crabs, were carried away by overflowing the retort lip into a collar and drain, attached to the top rim of the retort. Pressure-steaming the crabs was carried out by placing the crabs into an empty retort and cooking a 15 p.s.i. (250°F.) for ten minutes. Condensed steam was removed continuously by bleeding through the bottom of the retort.

TABLE 1

METHOD OF COOKING CRABS IN RELATION TO YIELD

Test	*Method*	*Live crabs* (lbs.)	*Yield (lbs. per batch)* Reg.	Lump	Claw	Total	*Yield* (%)
1	A	402	36.8	22.0	13.4	72.2	18.0
	B	402	40.0	23.0	17.0	80.0	19.9
2	A	467	40.0	21.8	16.6	78.4	16.8
	B	467	46.0	21.5	19.8	87.3	18.7
3	A	425	38.9	22.0	15.8	76.7	18.0
	B	425	43.8	17.7	17.6	79.1	18.7
4	A	407	35.9	21.5	15.3	72.7	17.9
	B	407	38.4	19.1	17.9	75.4	18.5
5	A	356	32.5	17.0	13.4	62.9	17.7
	B	356	36.7	17.4	17.5	71.6	20.1
6	A	362	32.0	13.4	8.2	53.6	14.8
	B	362	34.4	10.3	8.2	52.9	14.6
7	A	296	27.6	13.3	11.0	51.9	17.5
	B	296	28.8	13.3	13.1	55.2	18.6
8	A	439	28.8	14.0	10.5	53.3	12.1
	B	438	34.0	11.0	11.9	56.9	13.0
9	A	249	26.4	10.0	8.0	44.4	17.8
	B	249	28.1	9.5	10.6	48.2	19.4
10	A	380	34.1	16.4	12.9	63.4	16.7
	B	380	37.6	14.5	15.0	67.1	17.7
11	A	325	32.3	18.5	14.3	65.1	20.0
	B	325	33.5	16.5	16.1	66.1	20.3
12	A	300	27.3	13.5	9.9	50.7	16.9
	B	300	31.4	14.8	13.5	59.7	19.9
Total	A	4408	393	203	150	745	
	B	4407	433	189	178	799	
Average (12)			8.9%	4.6%	3.4%		16.9
			9.8%	4.3%	4.0%		18.2
B over A (%): lbs. per 100 lbs. crabs							1.3
lbs. per 100 lbs. picked meat							7.7

A - steamed 10 minutes at 15 p.s.i. (250°F.)
B - steam-boiled at 212°F. 15 minutes in tapwater

Results are summarized in Table 1. Pressure-steaming resulted in a recovery of 16.9 per cent total meat, based on 100 pounds of live crabs. Steam-boiling resulted in 18.2 per cent pounds total meat, which gave steam-boiling an advantage of 1.3 pounds of meat per 100 pounds of live crabs. Steam-boiling resulted in 7.7 pounds more meat per 100 pounds of picked meat than did pressure-steaming, an advantage which results in a monetary saving of about $1.25 per 100 pounds of live crabs.

Pilot plant tests were made, comparing the yield from forty batches of crabs steam-boiled at 212°F. for ten minutes, with forty batches of crabs pressure-boiled for ten minutes at 250°F. (15 p.s.i.). Each batch consisted of 100 pounds of crabs.

The results as shown in Table 2, indicate that the yield of crabmeat from the steam-boiled crabs was 17.6 pounds per 100 pounds of live crabs versus 15.9 pounds for pressure-steaming. The advantage for steam-boiling over steaming was 1.7 pounds of meat per 100 pounds of crabs. This would result in an extra monetary advantage of almost $1.50 per 100 pounds (barrel) of live crabs.

TABLE 2

YIELD, IN RELATION TO METHOD OF COOKING

	(%) lbs. crabmeat per 100 lbs. crabs	
	Range	*Average (40)*
Steam-boiled at 212°F.	15.5-19.3	17.6
Steamed at 250°F.	14.2-17.6	15.9

Yield of Various Types of Meat

Whether steam-boiling crabs at 212°F., or steaming at 250°F., the percentage of the various types of meat is similar. One hundred pounds of picked meat will consist of approximately 53 per cent regular white, 25 per cent of backfin lump, and 22 per cent claw meat. Table 3 shows the percentage yields of various types of meat.

TABLE 3

PER CENT DIFFERENT TYPES OF MEAT

	total	*regular*	*lump*	*claw*
Steam-boiled	100	53	24	23
Pressure-steamed	100	52	27	21
Average of 24 cooks	100	53	25	22

Seasonal Yield of Crabmeat

Table 4 shows the effect of seasons on yield (Littleford 1957). All of the crabs were obtained from the same source. Highest yields were during summer, followed by spring, fall and winter. Differences are not significant between summer and spring crabs, but are significantly lower during fall and winter.

The crabs were obtained at different times of the year and grouped into seasonal categories as follows: winter crabs, dredge crabs obtained from February 2 through March 15; spring crabs, May 9 through June 15; summer crabs, August 6 through September 13; and fall crabs, October 8 through November

5. Thirty cooks were made in each group, ten each at five, ten and fifteen minute cooking time at 250°F.

TABLE 4
SEASONAL YIELD OF CRABMEAT

Season	*lbs. meat/100 lbs. crabs**
Winter	14.9
Spring	16.5
Summer	16.9
Fall	15.8

*Average of ten cooks, at 250°F. for 10 minutes

Effect of Length of Cook

Crabs were steamed at 250°F. (15 p.s.i.): for five, ten, and fifteen minutes in one set of tests, Table 5; and for eight, twelve, and twenty minutes in another series of tests as shown in Table 6. Optimum length of time for steaming crabs at 250°F., seems to be from eight-ten minutes. Shorter or longer cooking time resulted in lower yields. Apparently five minutes is too short to allow proper weakening of the bond between the muscles and the skeleton, and as a result the crabs are undercooked and difficult to pick. Crabs that are overcooked, cooked too long, have meat that is dried out and also difficult to pick.

TABLE 5
EFFECT OF LENGTH OF COOK AT 250°F. ON YIELD

Sample	*Duration of Cook*		
	5 mins.	*10 mins.*	*15 mins.*
A	14.4*	14.9	13.5
B	15.9	16.5	14.7
C	14.7	16.9	14.5
D	15.0	15.8	14.3
Average of 40 cooks	15.0	16.0	14.2

*All figures represent: lbs. crabmeat/100 lbs. crabs

TABLE 6
EFFECT OF LENGTH OF COOK AT 250°F. ON YIELD

Sample	*Duration of Cook*		
	8 mins.	*12 mins.*	*20 mins.*
E	15.0*	13.5	13.2
F	15.9	15.1	14.6
Average of 24 cooks	15.5	14.3	13.9

*All figures represent: lbs. meat/100 lbs. crabs

Comparison of Crabs from two Locations

During the summer of 1957, female crabs captured in crab pots from Chesapeake Bay near Crisfield were compared with male crabs caught on trot

lines in the Choptank River. The crabs were cooked at 15 p.s.i. (250°F.) for eight, twelve and twenty minutes. Thirty-six cooks were made, (twelve for each cook time), on each set of crabs from the two different sources. (Table 7).

TABLE 7

PER CENT YIELD PER 100 LBS. LIVE CRABS

Area	*Cooking Time in Minutes at 250°F.* 8 min.	12 min.	20 min.	*Mean Yield*
Chesapeake Bay	15.0	13.5	13.2	13.9
Choptank River	15.9	15.1	14.6	15.2

The difference in mean yield of 1.3 per cent between crabs from the two sources is statistically significant. Despite this difference, the relative effect of cooking time on yield for each set of crabs was similar; the eight minute cooking time giving a significantly higher yield than the twenty minute. This demonstrates that differences in cooking yield occur between crabs from different localities. However, the relative effects of yield, of modifications in cooking time, are similar for both sets of crabs.

On the basis of the data on crabs obtained during different seasons of the year, and crabs obtained from different localities, it is concluded that although yields vary from place to place and season to season, cooking modifications affect all of the crabs in the same way. Studies on the effects of various cooking methods in crabs from one area can be applied to crabs from other areas.

Effect of Cooking Temperature

A study of the effect of different cooking temperatures on yield was undertaken, using tapwater at 212°F., 3 per cent brine at 213°F., 227°F., 239°F. and 250°F. (Table 8). The crabs boiled at 212°F. in tapwater showed significantly higher yields of picked meat than did the other four methods of cooking.

TABLE 8

YIELD, AS AFFECTED BY TEMPERATURE OF COOK

Treatment	*lbs. meat/100 lbs. crabs*
212°F., tapwater	14.9
213°F., brine 3%	14.3
227°F., 5 p.s.i.	14.1
239°F., 10 p.s.i.	13.6
250°F., 15 p.s.i.	13.4

Average of 30 cooks, each treatment

Table 9 shows the temperature-time relationship in crab cooking. Each temperature and treatment approaches an optimum time period. At lower temperatures 212°-227°F. cooking time, as long as fifteen minutes, does not critically affect yield. Brine-cooking seems to be the exception, since fifteen minute cooks reduced yield markedly over ten minute cooks. An explanation possibly is that sodium chloride leaching of soluble proteins may have occurred. At higher temperatures 239-250°F., ten minutes seems near maximum time limit over which time drastic yield losses occur.

TABLE 9

PER CENT YIELD AS AFFECTED BY COOK TREATMENT

Time Min.	*Boiling*		*Steam Temperatures*		
	Water	*Brine*	*227°F. (5 p.s.i.)*	*239°F. (10 p.s.i.)*	*250°F. (15 p.s.i.)*
5	14.2	13.8	13.9	14.3	14.7
10	15.2	15.0	14.1	13.9	14.4
15	15.3	14.2	14.4	12.7	11.2

Post-Cook Handling

Post-cook handling is important in yield, since, as the crab cools, it also dries and congeals. The meat in a freshly cooked warm crab is more likely to break into small flakes than is the meat in a cooled crab that has been allowed to dry out overnight. Table 10 summarizes an experiment involving 150 cooks, 30 for each method of post-cook handling. The following yields, expressed in per cent, were obtained: Deback refrigerate overnight 14.3, deback pick immediately 14.3, hold overnight at room temperature 14.1, refrigerate overnight 14.0, and pick immediately 13.7. When these results were studied it was found that the demonstrated differences were not statistically significant, that is, that the observed differences could have been caused by chance rather than by the differences that were being studied.

Table 11 shows the result of a pilot plant study, each treatment representing twenty cooks. Debacking and refrigerating crabs showed yields significantly higher, than did holding whole crabs overnight at room temperature before picking the meat.

TABLE 10

YIELD, IN RELATION TO POST-COOK HANDLING

Storage time and temperature	*lbs. meat/100 lbs. crabs*
Room temperature, overnight	14.1
Refrigerator, overnight	14.0
Pick immediately (hot)	13.7
Deback, pick immediately	14.3
Deback, refrigerate overnight	14.3

Average of 30 cooks, each treatment

TABLE 11

POST-COOK HANDLING IN RELATION TO YIELD

Treatment	*lbs. meat/100 lbs. crabs*
Steam-boiled: (10 mins. 212°F.)	
Whole crab, room temp., overnight	17.1
Debacked, refrigerated overnight	18.0
Pressure-steamed: (10 mins. 250°F.)	
Whole crab, room temp., overnight	15.3
Debacked, refrigerated overnight	16.5

Average of 20 cooks, each treatment

Conclusion

Maximum yield of crabmeat as shown by this investigation would likely be obtained under the following optimum conditions: Choptank River male crabs, obtained in summer, steam-boiled fifteen minutes at 212°F. in tapwater, debacked, chilled overnight at 38°F.

Acknowledgment

This research was carried out under the United States Bureau of Commercial Fisheries Contract #14-19-008-9323 (April 1957-October 1959).

REFERENCES

Littleford, Robert A.

1957. Retort cooking of blue crabs. Bull. No. 1, University of Maryland, Seafood Processing Laboratory, Crisfield, Maryland.

North Atlantic Tuna Explorations

James L. Squire, Jr.

Bureau of Commercial Fisheries, Gloucester, Mass.

This presentation was a verbal commentary on a moving picture. This 16 mm. color film may be obtained on loan from the Bureau of Commercial Fisheries, State Fish Pier, Gloucester, Massachusetts.

THURSDAY—NOVEMBER 12

Chairman—SETON THOMPSON, *Regional Director, U. S. Fish and Wildlife Service, St. Petersburg Beach, Florida*

Report of the Committee on Oceanography: 'What Does It Mean to Commercial Fisheries?'

HOWARD H. ECKLES
U. S. Bureau of Commercial Fisheries, Washington, D. C.

THE FISHERMAN'S LOT is not an easy one. He enjoys no 40-hour week, no guaranteed comfortable working conditions, company life insurance or retirement benefits.

He works long, irregular hours, away from home, in all kinds of weather, and frequently on rough waters. While he is at sea, sleep is a luxury; working days of twelve to eighteen hours are not uncommon.

Fishermen of the north experience extreme cold that freezes their nets and blocks on deck so that they must be thawed with heated sea water. Sometimes their ships become dangerously unstable from frozen spray which must be chopped loose and thrown overboard.

Fishermen of the south sometimes suffer spoilage of their catch in hot weather before it can be delivered to market.

All fishermen suffer the vagaries of nature, of scarcity at one time, overplenty at another. Economic conditions act in various ways to alter prices. These factors add to the fisherman's problems by providing a fluctuating, undependable income.

We lack understanding of nature's effects upon fish abundance, and the effect of these changes upon all types of fishing, whether it be trawling for shrimp or groundfish or harvesting of coastal oysters and clams.

Oyster fishermen work hard to plant shell and seed, often to find that an unknown disease or a hurricane has spoiled the harvest.

Fishing is not now an efficient process. A trawl catch on the Grand Banks may contain five to ten thousand pounds of many types of fish. But our technology and markets allow the use of relatively few varieties. Consequently, a considerable amount of protein is washed back over the side after fishermen have expended labor to catch it.

When fish or shrimp are delivered ashore, they may not be acceptable for market because delays in fishing or weather may have allowed bacterial decay to spoil the catch. Desirable species of food fish often end up in a meal plant, for a fraction of their value had they been landed fresh from the sea.

Improvements in methods of catching and processing fish have been made in recent years, but, on the average, fisheries of the United States have declined in relation to other food-producing industries. Many segments of the United States fishing industry are facing difficulties which are causing them to shrink, to lose their former position of importance in the United States economy. In 1950 there were about fifty large trawlers fishing Georges Bank in the North

Atlantic Ocean. Now there are about thirty. Young men are not entering this industry. It is not attractive to them financially, and the work is hard. The fleet of tuna vessels working out of California ports is shrinking. As vessels become old they are not being replaced. The shrimp industry of the South Atlantic and Gulf Coasts is experiencing economic difficulties from imports and severe competition between fishermen for shrimp available on the fishing grounds.

How can research in oceanography help the fishing industry?

Assume that through oceanographic studies in the future we have complete knowledge of how fish react to combinations of various stimuli, and that we can apply this knowledge to catch fish from wide expanses of the ocean, either from the upper waters or the bottom.

For example, we know now that some fishes make noises and that some will react to sounds of various kinds. They might be attracted or repelled by sound vibrations of the right frequency and intensity.

Similarly, fish will respond to traces of chemicals, to visual barriers such as a curtain of air bubbles, or black dyes, or to light. Their movements can be controlled by electricity.

A fishery of the future, say on Georges Bank, might operate as follows:

An underwater craft, possibly powered by an atomic reactor, is used to scout a five-mile area to chart distributions and numbers of fish. The search for fish is made with the aid of underwater television, echo rangers and by direct visual observations. Next, four surface vessels, one mothership and three smaller ones, following directions from the undersea craft, approach from the edges of the area, towing sound vibrators which herd or drive fish towards the center of the circle.

Slowly, these vessels converge reducing the circle of sound until fish are concentrated within a radius of a half mile. One vessel is then detached from the others, which continue to hold the sound barrier, and an electric cable and chemical dispensing hose are placed around the group of fish. This will then be drawn in, concentrating them into a circle of a few hundred yards, using traces of chemical solutions and visual dyes to tighten the web of control.

Next an electric current pulls the school tight and raises it to large pumps where it is drawn aboard the mothership.

With suitable manipulation of the electric current the catch is sorted by size —perhaps even by species—as fish are pumped aboard. Those which are destined for filleting could be drawn aboard first, those for reduction to meal and oil later.

Next, conveyor belts carry the food fish through filleting machines, after which they are packaged and frozen or preserved by atomic radiation. The fish are processed in prime condition in less than an hour after being taken from the sea. This whole operation, resulting in the catch of all fish of the desired species and size in a five-mile area, has required about two hours.

Georges Bank, or a similar vast area of the sea, is fished with a few specialized vessels during ideal conditions of season and weather. Fishermen work in heated or air-conditioned compartments instead of handling fish in freezing weather or under the hot sun.

This highly efficient method of fishing, admittedly rather imaginative in terms of today's knowledge, can be achieved provided we learn enough about the sea and the fish in it. It presupposes that we know as much about animals in the sea as the farmer does about those on land. We must know: (1), how many fish of all kinds are in the sea, (2), how they are distributed, (3), what factors

control their abundance, (4), how they respond to various stimuli, (5), how they can be caught at the right time in their life to ensure maximum production and (6), how many to spare so that future production is assured. The last item is very important. For each species, we must know the maximum rate at which fish may be caught and still assure future production, for with such efficient methods of fishing it would be easy to reduce abundance quickly and endanger spawning stocks. Thus knowledge derived through oceanography can lead the way to wise fishing practices, better working conditions, and reduce production time and costs.

Besides revolutionizing our methods for harvesting the open sea, new research can lead to development of other ways of producing fishery products, for example, farming the edge of the sea, growing shrimp, crabs, oysters, clams and fish in ponds or portions of estuaries. Under such controlled conditions, more desirable products could be developed through selective breeding, predators could be controlled, the environment manipulated, and the animals fed on highly nutritive diets for rapid growth. Fish and shellfish could be grown to market size in a few months. The fishing industry might become known for "Beltsville" shrimp or Black Angus oysters as agriculture has become famous for certain strains of turkeys and cattle.

A realization of the need for the United States to gain more from the oceans, through increased resource production, improved transportation, better understanding of climate, and greater protection against military attack, led the National Academy of Sciences to examine the Nation's needs for oceanographic research. The Committee, organized in 1957, made a survey of the present status of the marine sciences in the United States. Its report, "Oceanography 1960-1970," (National Academy of Sciences—National Research Council 1959) contains recommendations which can strengthen marine sciences and, among other things, lead to greater development and utilization of ocean resources.

The Committee found that relative to other scientific endeavors progress in marine science has been slow. Research undertaken in the past has been done under difficult circumstances, handicapped by insufficient manpower, ships, and shore facilities. In the field of ocean resources, this has prevented an adequate understanding of the occurrence, behavior and potential harvest of fish and many other marine organisms. This lack of understanding is a serious barrier to their full economic development and utilization.

The Committee has, therefore, recommended that research on fishery resources be expanded over the next ten years. New information should be produced which will help fishermen improve methods of harvesting. Research on fish behavior, physiology, response to stimuli, and genetics of marine animals has been stressed. New knowledge gained about the oceans and its life can lead to new ways of fishing and of growing fish and shellfish even more startling than those described here.

Research and surveys have been recommended which will define potential yields of latent fisheries and reduce fishing costs by predicting times and places where fish concentrate. It may even be possible to modify the marine environment and thus improve fish survival and smooth-out abundance fluctuations.

It is easy to foresee that, in time, wide expanses of the open ocean and many coastal areas will be fished or farmed to increase our protein supply. Many species, not now utilized, will be brought to market. There will be need for radical changes in methods of fishing and in our concepts about use of products from the sea. The National Academy of Sciences has told scientists, Govern-

ment, and the fishing industry what must be done to accomplish this goal. The gains can be substantial but only after long-term, painstaking research, which should be started without delay if we are to compete with other countries or even maintain our present position among the fishing nations.

LITERATURE CITED

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL
1959. Oceanography 1960 to 1970. A Report by the Committee on Oceanography. 1. Introduction and summary of recommendations. 33 pp. 3. Ocean resources. 30 pp. Washington, D. C.

The Effects of Pesticides on Sport Fisheries

DANIEL H. JANZEN
Director, Bureau of Sport Fisheries and Wildlife, Washington, D. C.

Abstract

Pesticides for agricultural use are being applied at such great rates in the United States that they must be considered as a major factor in the welfare of our fishery resources. It has so far been impossible for fishery research to keep up with the growing use and increased potency of these chemicals, but recent legislation directing the Secretary of the Interior to undertake comprehensive research on the effects of pesticides on fish and wildlife has dramatized the need for careful study. The insecticides pose the greatest threat to fish; of these, the chlorinated hydrocarbons are most dangerous because of chemical stability and slow detoxification. The Bureau of Sport Fisheries and Wildlife has organized a laboratory at Denver, Colorado, for research on the complex of fish, water, fish food, and pesticides, involving both biological and biochemical studies. The laboratory's program will include cooperative work with entomologists and chemical industry scientists to develop more specific and less toxic pesticides and improved methods of application.

THE MANAGEMENT of the inland sport fisheries has always had to consider the factors which tend to reduce fish populations. The effects of exploitation by fishermen, the survival of planted fish, and the improvement of the environment have been intensively studied, and progress has been made in maintenance of sport fish populations as a result of understanding these factors and applying improvements. Fishery science has made good progress in fresh water in providing fish for the creel, and in maintaining fish populations at safe levels. This has been possible because of long experience, long-term research, and hard work.

A relatively new threat has been added to the list of influences which adversely affect fish populations. Pesticides, including insecticides, weed killers, and other economic poisons, have come into such widespread use since World War II and have proven to be so poisonous to fish that they must now be ranked as a major factor in the welfare of sport fish in nature. Fishery biologists have been aware of the threat from pesticides for a long time; but it has been impossible to keep pace with the growing use of these toxicants in so many situations and in such widespread applications in the face of the augmented number of new agents, and with the increased potency of the newer insecticides.

Over 200 pesticides and more than 6,000 brand-named products are now marketed.

Extent of Pesticide Use

The use of economic poisons in the United States has undergone a phenomenal development from the days of the initial improvements in older botanical and inorganic pesticides. Just before World War II, advances were made in the areas of synthetic organic herbicides and fungicides. During the war, hormone-type selective herbicides, synthetic organic rodenticides, and chlorinated hydrocarbon insecticides were developed, and since the war, organic phosphate and systemic insecticides, anti-coagulant rodenticides, and antibiotics for plant use have been discovered and improved to an astounding degree. In more recent years, new and amazingly toxic halogenated hydrocarbons have evolved and have been marketed for mass application over widespread areas. The list is not complete without mentioning defoliants, plant growth regulators, nematocides, fungicides, and evaporation control agents. Truly, the term "chemical age in agriculture" is most appropriate in describing the latter-day methods of managing plant resources. Secretary of Agriculture Ezra Taft Benson points out that America's farmers need weed killers to prevent $4 billion per year in weed damage and enough rodenticides to prevent damage amounting to $1 - $2 billion per year. It is said that enough insecticides must be used to save seven billion board feet of timber in the United States each year. The farmers of the U. S. spent $400 million for pesticides in 1956; one can visualize the anticipated growth of this industry by noting that, by 1975, $1 billion worth of agricultural chemicals is expected to be used each year.

The growth of research on the effects of pesticides on sport fish populations has been very much slower than the development and use of new economic poisons. With the advent of DDT, fishery biologists became concerned about the consequences of field treatments near aquatic environments. Studies were conducted at the end of World War II to measure effects of DDT on fish and fish foods, and enough information was collected to make recommendations to reduce hazards to aquatic life. An increasing amount of investigation was done in subsequent years, but it was still difficult to keep pace with the strides of industry in their production of new and greater quantities of toxicants. Fishery science in the United States is responsible for the management and protection of sport fishery resources worth $2 billion per year, so we are discussing something that approaches in value some of the agricultural resources that are being protected by the pesticides. Industry is now spending $20 million per year on research and development in pesticides, and the Federal Government is dedicating $5 million per year to work with pesticides. Of course, only an insignificant fraction of this Federal money has been spent on fish studies, despite the desperate need for such investigation.

Considerable relief from this situation was afforded in 1958 with the passage of Public Law 85-582. This directed the Secretary of the Interior to undertake comprehensive studies on the effects of insecticides, herbicides, fungicides and other pesticides on the fish and wildlife resources of the United States. A small portion of the appropriated funds was applied to studies on fresh water fisheries, beginning in January, 1959. Some of the money was also used for marine fishery investigation. Construction of laboratory facilities was begun in Denver, Colorado, and I am happy to report that the specialized facilities needed for this work are now operating. The assembling of our staff of biologists and chemists was completed by the end of June, so the Fish-Pesticide Research Laboratory is an operating unit.

The directive for "comprehensive" work was nullified to a large extent by Congressional limitation on expenditures, so that no more than $280,000 could be appropriated in any one year. Congress recognized the deficiency during the past session and amended the 1958 Act to allow appropriations of not to exceed $2,565,000 a year for this work. We do not have any such appropriations now, but at least there is more room for budgeting realistically in accordance with the size of the problems involved.

Control Programs

Of all the pesticides, the insecticides pose the greatest threat to fish. This is so because of the magnitude of the spray programs against insects, because of the relatively high toxicity of insecticides as compared with weed killers and other economic poisons, because insect life is a major fish food and because of the variety of ecological situations in which insecticides are dispersed. Two chemical groups are the most important in the insecticide realm, the chlorinated hydrocarbons and the organic phosphates. The chlorinated hydrocarbons are characterized by moderately to extremely high toxicities to fish and by chemical stability that results in slow detoxification and prolonged danger to fish and fish foods. DDT is the most familiar insecticide of this group; aldrin, dieldrin, endrin, and heptachlor are examples of newer, long-lasting, and highly-toxic chlorinated hydrocarbons in widespread use today.

The organic phosphorus insecticides have a wide range of toxicity to fish, are generally less toxic to fish than many chlorinated hydrocarbons, and lose their toxicity much more quickly than most chlorinated hydrocarbons, especially in aquatic environments.

The method of application of the insecticide and the formulation in which it is applied are of decided importance in the effects on fish. Airplane spraying, although cheap and fast, is often difficult to control, and is generally less safe in the vicinity of water than ground spraying or dusting which features lower dosage rates and better control over distribution. Oil solutions are very popular as formulations for many insecticides, and are favored from the fish standpoint because of their lower toxicity compared with xylene emulsions and because of their fast dissipation compared with dusts and wettable powders.

The herbicides represent the second greatest threat among the pesticides, especially those that are used to control aquatic weeds. When some weed-killers are placed in drainage and irrigation canals for aquatic weed suppression, there is often a danger to fish in the ditches and to waters into which the canals may feed. The dinitrophenol compounds, the aromatic solvents, and the chlorinated benzenes are herbicides that are particularly hazardous to fish; the 2-4D and 2-4-5T weed killers have proven to be somewhat less toxic for fish and fish food animals.

Some recent insect control programs in the United States have been so large and have attracted so much attention that some remarks about them may be in order here. The larger programs include spruce budworm in the forest areas of the north, gypsy moth in the northeast, mosquitoes in nearly all parts of the country, grasshoppers in the west, and imported fire ant in the southeast. In the past four years, approximately 26 million acres of forest and agricultural land have been treated for these pests alone, and projected plans call for augmented control programs for control of some of these insects. Spruce budworm and gypsy moth programs feature aerial application of one pound per acre of DDT, a procedure that has resulted in cases of substantial losses of trout in

New Brunswick and Montana. In the fruitfly eradication effort, malathion bait spray is dispersed by airplane and ground equipment at the rate of ½ to ¾ pounds per acre of the poison. Here again, actual control operations have produced extensive mortality to shallow-water fish populations in Florida. Insecticides of various kinds are in common use for grasshopper control in the west —dieldrin, heptachlor, endrin, chlordane, aldrin, and toxaphene in relatively low dosage rates. In 1958 and 1959 several instances of significant mortalities among bass, bluegill, crappie, and perch populations in lakes in Colorado were observed following airplane spraying of aldrin, toxaphene and endrin. Alarming as these documented episodes have been, we are faced with a still stronger possibility of damage to fish and fisheries in parts of the southeastern U. S. adjacent to areas to be treated for the protection of agricultural crops. Massive doses of insecticides are the treatments of choice for cotton and other crops, and heavy doses of dieldrin (2 pounds per acre) and heptachlor (1¼ pounds per acre) are being used and are planned for future, expanded imported fire ant eradication. Our knowledge of toxicity of these agents against fish causes us much concern about the consequences of these field programs, since these chemicals are among the most lasting and the most toxic in use today.

Damage to Fish

The damage rendered to fish by pesticides can act in one or more of several ways. Some poisons strike directly at the fish, causing acute toxicity and quick death. The mode of action may be on the central nervous system of the fish, as with chlordane, which stimulates the system, or with some isomers of benzene hexachloride, which depress the system. Organic phosphorus compounds are believed to act through irreversible cholinesterase inhibition by irritation of surface tissues, by stimulation and depression of the central nervous system, or by degeneration in the central and peripheral nervous system. Parathion, malathion, Chlorthion, and Guthion are poisons of this group. Chemicals of the pyrethrum type may be lethal to fish by causing convulsions leading to respiratory failure. Sometimes the solvents, as well as the insecticides, are toxic to fish. Kerosene has a narcotic action causing depression and can damage liver and kidneys. Xylene irritates nervous membranes and the skin, and affects red blood corpuscles.

Death to fish may be caused by the accidental or careless introduction of the chemical into waters during spray operations. Other chances for lethal amounts may be provided when long-lasting chemicals are washed into the water by rain runoff from adjacent ground or vegetation, sometimes long after the actual spray operation. Dieldrin, for example, has maintained its potency for more than two years in some instances and has poisoned fish over that period.

The presence in fish waters of invertebrates dying or dead from pesticide treatment can seriously affect fish. During such episodes, fish feed vigorously, engorging themselves with food animals that contain more toxicant than the water. It has been demonstrated that fish can die from acute toxicity after receiving chemicals from this source.

Another important influence pesticides may have on fish comes through destruction of the food supply. Aquatic invertebrates succumb to pesticides to various extents, and the effects on fish populations can obviously be serious. Starvation in fish can result in diminished growth rates and various deficiency maladies, or, when demands are placed on stored nutritive materials, may mobilize toxicants retained in adipose tissues.

The possible significance of chronic effects of pesticides must be emphasized here. The earliest concern for fish was naturally felt in terms of acute mortalities, but as fishery biologists worked on these toxicity problems, they developed an awareness of the possible import of chronic effects—effects which may well prove to influence fish populations more seriously than the quick deaths of whole segments of the populations. Since it has been established that low levels of some chlorinated hydrocarbons can reduce reproductive efficiency in gallinaceous birds, it seems possible that similar influences could occur in fish. As pointed out earlier, growth rates can be affected, either through elimination of the food source, or perhaps in a more direct way, affecting the physiology of the fish itself. Changes in behavior might come about through exposure to sublethal amounts of pesticides, and other life processes may be profoundly influenced by prolonged contact with small amounts of chemicals accumulated in food organisms.

Research to be Done

The foregoing remarks have been intended to reveal the magnitude of pesticide use, the diversity of programs which may affect fish, and the variety of ways in which the poisons have been shown to act on fish. We have only begun to scratch the surface in our search for an understanding of the complex involving fish, water, fish food, and pesticides. An intensive and extensive long-term program of basic research constitutes the task of the Fish-Pesticide Research Laboratory in Denver. Biological and biochemical studies are being initiated in an integrated program designed to furnish bases for predicting the immediate and long-term effects of pesticides on fish.

One important segment of the Denver program pertains to the determination of toxicities and tolerances of commonly used insecticides and fish. In this project we shall compare different chemicals, formulations, species of fish, sizes of fish, chemistries of water inhabited by fish, physical features of the environment, and other variables known or suspected to influence the welfare of fish populations subjected to exposure to economic poisons. These data are required as a starting point for more penetrating inquiries, and will be approached through controlled experiments in aquaria. Identical studies will also be made on important fish-food animals to help our view of some possible indirect effects on fish.

Concurrent with this will be basic studies in the chemistry laboratory, where we shall investigate characteristics of the toxicants and their biochemical effects on fish. This will include analyses of water, bottom sediments, aquatic vegetation, fish tissues, and invertebrate animals for presence of poisons and their metabolites after contact. Thus, we hope to trace the fates of poisons through water, food chains, and fish to determine the breakdown or buildup of toxic substances. This, of course, will be related to morbidity and mortality in the fish. The approaches in this program will be through chemical analysis, bioassay, and radioisotope tracing.

The program outlined above will gradually lead into fundamental studies on chronic effects on fish. We shall investigate influences on fish growth, on reproduction, on behavior, and on tissues and systems in the fish. With outdoor holding ponds, we can keep fish for extended periods and measure slow changes over long periods.

While this laboratory work is in progress, contact will be kept with actual control programs being carried on by other agencies in the field. By carefully

planning field work in connection with these projects, much valuable information and material for examination in the laboratory will be gained, and will thus bolster our laboratory results. Moreover, by participating in these projects, we are able to render services by giving advice and information to the control operators.

An important part of the program will include cooperative work with entomologists and members of the chemical industries to try to develop more specific and less toxic pesticides to help bring about effective pest control but with minimum hazards to fish.

We feel that this projected program, carried out carefully and vigorously, will be a major contribution to sport fishery management in the United States, and, indeed, in other parts of the world where the use of pesticides is increasing. The research program is aimed toward securing the answers needed by management personnel in the control of fish populations endangered by pesticides. Research of this type will equip the fishery manager with the means for accurately predicting the effects on fish of specific pesticide treatments. We look toward the day when the biologist can make a scientific appraisal of the fish population and the chemical and physical characteristics of the water before any treatment and calculate the amount of damage that will result. We are confident that fishery science is beginning the research that will bring this about, and in not too many years.

Clay-Mineral Sediments As A Reservoir For Radioactive Materials In The Sea[1]

K. M. Rae and R. G. Bader
Department of Oceanography and Meteorology
Texas A. & M. College, College Station, Texas

We are all too aware that any title which has in juxtaposition the expressions "radioactive materials" and "in the sea" automatically becomes controversial in this day and age. It is not our intention here to side either with the British who pump free liquid containing upwards of 10,000 curies each month into the Irish Sea only three miles from their coastline or with public opinion in parts of America which appears apprehensive about the suggestion that some 20 curies a month might be deposited safely in selected inshore areas if contained in concrete and iron drums.

Whatever one's views may be about sea-disposal of low level wastes, the fate of radio-chemicals which may find their way into the sea is a most important problem. Nuclear powered submarines and surface ships are things of the present and nuclear powered aircraft of the near future. Nuclear weapons may well be tested further, if not used in anger. Undoubtedly from now on, every year will see a steep increase in the amount of radioactive material created by man and in the variety of his uses of nuclear power. So the chance of fission products finding their way into the sea by accident or intent will grow correspondingly and inevitably.

In the simplest—but quite unrealistic—model, one can visualize complete

[1]Contribution from the Department of Oceanography and Meteorology of the Agricultural and Mechanical College of Texas, Oceanography and Meteorology Series No. 159.

dispersion of all radioactivity introduced into the sea over the total volume of sea water, some $360X10^6$ cubic miles. In such a situation the specific activity could be raised until it reached some upper level compatible to man's safety. Thereafter the permissible addition could be no more than would offset the natural loss of activity by decay to stable isotopes.

In any more realistic model, one finds factors tending towards this simplest solution and others tending to prevent it. Amongst the first category are all the physical processes associated with water movement and diffusion. Amongst the latter are the reverse processes leading to concentration and uneven distribution; prominent amongst these is, of course, the effect of particulate matter in the sea, both animate and inanimate. Clearly, plants and animals by involving radioisotopes in their metabolism may concentrate them well above the dilution in the surrounding sea water, and then redistribute them in increasing concentrations through complicated food chains. Migrations, swarming and schooling habits may also tend to redistribute radioactivity that becomes involved in living animals.

Inanimate particles have an analogous, if less obvious, function resulting from the process of "sorption." Clay-mineral particles are highly efficient scavengers of organic molecules and thus of any cations which may become complexed with these molecules. A good deal of work has been done on this by soil-chemists but relatively little is known quantitatively about the process in the marine environment. We do know, however, that marine sediments often contain a considerable organic fraction and that sediments when in suspension can remove a high percentage of dissolved organic substances from a liquid medium by some sorptive process. From the practical aspect, for example, the sediments immediately around the outfall from the Windscale reactor in Britain have become relatively hot through this process. And shaking with clay-minerals has often been proposed as a technique for decontamination of radioactive solutions.

As part of a program sponsored by the U. S. Atomic Energy Commission, we have been investigating these scavenging properties of sedimentary particles. So far emphasis has been on simple systems—the capacity of various minerals to take various organic substances out of solution. As examples, we can consider the ability of montmorillonite, kaolonite, illite and quartz to accumulate glycine, succinic acid, sucrose and fructose. In general terms the experimental techniques have been as follows.

C^{14} labeled solutions of glycine, succinic acid, sucrose and fructose were made up in 4 concentrations ranging from 0.1 to 1.2 gm/100 ml. and duplicate 500 λ samples were pipetted from each. Each sample was then dried in a planchet containing lens paper and counted in a Nuclear Chicago automatic sample changing Gas Flow Proportional Counter or alternatively the sample was pipetted into a scintillating liquid in 22 ml. K-40 free vials and counted in an Automatic Packard Tri-Carb Liquid Scintillation Spectrometer. A known weight of clean mineral was placed in a 40 ml. tube and wetted with 1 ml. of deionized water. Ten ml. of the C^{14} labeled organic solution was then pipetted into each 40 ml. tube containing the wetted mineral and the tubes were shaken for 20 minutes. After settling, two 500 λ samples of the supernatant were taken off and counted in the manner described above. The difference in radioactivity between the original solution and the supernatant gave a measure of the organic material removed from the solution by the mineral.

TABLE 1

PERCENTAGE RETENTION OF ORGANIC COMPOUNDS BY 20 MG. OF MINERAL

	5°C.			
	Montmorillonite	Illite	Kaolinite	Quartz
Sucrose	71	30	9	2.5
Fructose	55	19	7	2
Succinic Acid	44	15	5	2
Glycine	36	15	3	1
	10°C.			
	Montmorillonite	Illite	Kaolinite	Quartz
Sucrose	71	31	8	2.5
Fructose	40	11	5	1
Succinic Acid	17	4	1	0.5
Glycine	10	4	1	0.5
	15°C.			
	Montmorillonite	Illite	Kaolinite	Quartz
Sucrose	30	10	3	1
Fructose	66	23	7	2
Succinic Acid	20	8	2	0.4
Glycine				

Data obtained at temperatures of 5°, 10° and 15°C. are given in Table 1. From this it can be seen that montmorillonite removes the greatest percentage of each organic compound from solution, illite next, then kaolinite and last quartz. This can be explained on the basis of active surface area.

Over the entire concentration range there is a linear relationship between the solution concentration and the organic uptake. It should also be noted that montmorillonite is capable of removing from solution 3.5 times its own weight of organic compound. For example, 20 mg. of montmorillonite can retain 70 mg. of fructose or sucrose at solution concentrations of 100-110 mg/10 ml. This can hardly be explained on the basis of adsorption. For the present this system can be best visualized as a complex clay-organic gel.

Apparently adsorption does occur at low solution concentrations. In one instance kaolinite-fructose concentrations ranging from 0 to 1.0 mg/10 ml were investigated and normal adsorption isotherms were observed.

Let us suppose, as is almost certainly true, that the natural sediments and detritus which are in temporary suspension in the sea scavenge out by sorption a proportion of the dissolved organic material and with it a proportion of the more hazardous isotopes that happen to be there. What effect will this have on the distribution of radioactivity in the sea and its potential danger to man?

On the one hand, it may be argued that this process is a factor tending towards safety. It has been suggested that as the sediments sink to the bottom and form successive layers, they will remove radioactive elements from the water and contain them in such a way that they are no longer available to the biota. In other words, we have in the sea a natural scavenging and burying system which will be particularly efficient in inshore waters where run-off

insures a plentiful supply of sorptive particles. There might be a counter danger of such hot sediments being transported to beaches and so interfering with recreational facilities, but the process would mitigate against the primary hazard of the radio-nuclides re-appearing in man's diet incorporated in seafood. To put this argument into perspective, one can quote from the recent publication (No. 655) of the National Academy of Sciences-National Research Council, which contains a very vivid appreciation of the practicability of "Radio-active Waste Disposal into Atlantic and Gulf Coastal Waters."

> "Because we are unable to make a quantitative estimate of the magnitude of uptake on suspended and deposited solids, we have neglected this factor in our evaluation of the quantities of wastes likely to be found in the water and in marine food products for various rates of disposal of radioactive wastes. We believe that by neglecting this factor our recommendations concerning disposal rates include a safety factor of at least 10, and possibly more."

As a counter argument, however, it can be proposed that this very process may increase the over-all hazard. It may be feared that certain benthic animals can strip the sorbed materials from sediments despite its bonding. Then two dangers arise. Firstly, filter feeding animals, including those exploited commercially, may themselves become radioactive or pass radioactivity on to their predators. (The authors of the NAS-NRC publication No. 655 noted this point and wisely postulated that no disposal should be permitted near areas exploited by commercial fisheries.) Secondly, seasonal fluctuations in the abundance of such animals may lead to a more or less sudden release of the radioisotopes which have accumulated in the sediments over several months of sorption.

In considering such possibilities, one immediately thinks of the potential role of bacteria in recycling sorbed radioactive materials either by direct release or by making them more available to those animals which may pass the sediments through their digestive systems. It is well known that bacteria proliferate rapidly in the presence of discrete particles that provide a suitable substrate. Sedimentary particles certainly provide a suitable diffuse substrate but can the bacteria utilize the potential source of nutrients that is bonded to it?

Quite recently we have started some experiments to try to find out. We emphasize, however, that this project, also sponsored by the U. S. Atomic Energy Commission, is only in its preliminary stages. We are now only looking for suitable experimental areas and possible techniques. The preliminary results, if suggestive, cannot be considered convincing until more rigorous experiments have been conducted.

For the first trials we needed labeled organic material typical of that naturally occurring in sea water. To obtain an approximation to this, unicellular marine algae, *Platymonas* and *Phaeodactylum,* were grown in mass culture in a medium in which a high proportion of the carbon was the C^{14} isotope. These cultures were then killed, mascerated, and run through a Millipore filter. The filtrate was shaken with montmorillonite. The clay was then removed and washed several times. A considerable amount of the organic material and its associated radioactivity remained on the clay.

To get a general idea of whether marine bacteria could utilize or release the organic material from such clay, twenty-one flasks were set up in seven sets of three. Each flask contained 40 ml. of ZoBell's culture medium #2216, modified to the extent that the peptone enrichment was reduced from 5 gm/L to 2 gm/L.

To each flask was added 1 gm. of the labeled montmorillonite which had an activity of about 2,000 counts per min/gm in a gas flow counter. The pH was then adjusted to 7.9. Next, six sets of three flasks were inoculated with marine bacteria using a different strain in each set. The seventh set was not inoculated and although not necessarily completely sterile, presumably contained relatively few bacteria and none of marine origin. The whole battery of flasks was allowed to incubate for seven days. The supernatant was then drawn off, and the clays were washed and counted. The results are shown in Table 2.

TABLE 2

ACTIVITY OF ABOUT ONE GRAM OF MONTMORILLONITE AFTER INCUBATION WITH VARIOUS STRAINS OF BACTERIA FOR ONE WEEK.

	Bacterium Strain	Cultures A	B	C	Average cpm*
(1)	10 BGP	489	495	423	469
(2)	14 TG	559	560	483	536
(3)	18 TGA	618	697	586	639
(4)	19 TG	653	750	600	668
(5)	16 TG	748	794	718	753
(6)	16 TGB	650	744	(1,100)	831
	Clay:	1261	880	1125	1089
(7)	Control Supernatant:	903	1302	1163	1122

*Counts per minute.

Rather surprisingly, about half the radio-activity found its way off the clay in the control flasks but it is most unlikely that this was entirely due to leaching or washing. Almost certainly the supernatant contained an appreciable fraction of the montmorillonite which very readily goes back into suspension.

However, be this as it may, it is obvious that the removal of activity from the clay was about twice as much in the flasks that had been inoculated with bacteria.

Counting the clays, rather than the supernatant, presents some technical problems. Firstly montmorillonite after exposure to salt water and organics does not readily dry in the planchets to a consistent geometry. Secondly, the particles, although previously exposed to the labeled algal material, take up a considerable added load from the organic enrichment of the culture medium. This added uptake varies under different experimental conditions, so it becomes difficult to refer the counted activity back to a unit weight of clay. Further, the distribution of organic material and dried salt in the sample will vary back-scattering and self-absorption, and so preclude any standard correction for thickness. In view of this, and the fact that it is not easy to ensure equal inoculations of bacteria in every flask, it was encouraging to find how well the counts agreed within replicate series. It was presumed that in the one really anomalous result, flask 6C, the bacteria failed to grow.

Subsequent experiments have shown that bacteria will grow for a time in a system comprising unenriched synthetic sea water in which the only organic source is the algal material sorbed on the clay. More recently too, we have been trapping and counting the respired $C^{14}O_2$ from each flask. Such further results are substantially the same as those given in Table 2. There is thus every indica-

TABLE 3

AVERAGE COUNTS PER MINUTE PER GRAM DRY WEIGHT OBTAINED FROM HOMOGENIZED TISSUE OF SMALL FISH 96 HOURS AFTER FORCE-FEEDING WITH LABELED CLAY.

Tissue	*F. similis*	*G. felix*
Gill	8,900	14,795
Digestive tract	4,030	2,520
Rest of body	610	430

tion that marine bacteria can hasten the release of sorbed organic materials from the sediments.

Other preliminary trials were made to see whether the sorbed organic materials were available to benthic animals. In each case, labeled clay slurries were prepared in the manner described above by suspending montmorillonite in a solution of disintegrated algae that had been grown in a C^{14} medium.

In one series small fish, mud-puppies (*Fundulus similis*) and sea cats (*Galeichthys similis*), were force-fed by pumping labeled clay directly into the gut through the mouth by means of a syringe. Each fish was then put in clean sea water for thirty minutes to wash off any slurry which might be regurgitated, washed again, and finally transferred to solitary confinement in 1,500 ml. of 28 p.p.t. sea water. After 96 hours the fish were killed, washed in dilute HC1, and dissected into three parts: the gills, the alimentary canal and the rest of the body-tissue. Each of these fractions was homogenized in 3 ml. of distilled water in a Serval Omni Mixer for fifteen minutes, dried in a planchet, weighed and counted for five minutes in a gas flow counter. The counts are shown in Table 3.

In other experiments, mussels *(Modiolus modiolus)* and oysters *(Crassostrea virginica),* were kept in bowls containing 1,500 ml. of filtered sea water to which labeled clay had been added and allowed to settle for twenty-four hours. After certain periods, individual animals were sacrificed and their entire soft parts were removed, washed, homogenized, dried, weighed and counted in the same manner as used for the fish. Average counts are given in Table 4. Two white shrimp (*Penaeus setiferus*) were treated in essentially the same manner (Table 5).

It must be emphasized that the counts listed in Tables 3, 4 and 5 have little quantitative value; strictly speaking, they are not even inter-comparable. As mentioned above, the object was first to obtain qualitative observations that might demonstrate the ability of the animals to remove the organic material from the clay. At this stage no corrections were available for self-absorption, which may well vary between different tissues. The samples counted were small, so the counts must reflect sample weight which also varied considerably.

TABLE 4

AVERAGE COUNTS PER MINUTE PER GRAM DRY WEIGHT OBTAINED FROM HOMOGENIZED SOFT PARTS OF MOLLUSKS AFTER EXPOSURE TO 2 ML. OF LABELED CLAY IN 1500 ML. OF SEA WATER.

Exposure time	*M. modiolus*	*C. virginica*
24 hr.	no data	1960
96 hr.	562	1390
14 days	210	75

We have not yet adequate evidence to say with confidence that the animals were able to utilize the clay-sorbed material in their metabolism. It is, however, clear that a proportion of the radioactivity found its way off the clay and became associated with the animal tissues. There remains the possibility that the labeled organics were transferred from the montmorillonite to the animals by solution and re-adsorption; the high activity of the shed exoskeleton of *P. setiferus* demonstrates that this may be an important factor. However, the fact that the soft parts of the mollusks were radioactive during the first four days and some activity was detected in the internal tissues of the shrimp and fish suggests that surface adsorption is not the only process involved. The very high counts from the gills of the fish may also imply metabolic excretion of the C^{14} placed in the gut.

It now remains to repeat experiments in a quantitative basis measuring in absolute units of activity. This is being done.

We are indebted to the U. S. Atomic Energy Commission for financial assistance (Contract AT-40-1-2061), to many colleagues who are cooperating in the program, and in particular to Mr. Tom Duke, Mr. E. Traganza and Mr. J. B. Smith who undertook the experiments cited above.

TABLE 5

COUNTS PER MINUTE PER GRAM DRY WEIGHT OBTAINED FROM HOMOGENIZED PARTS OF *Penaeus setiferus* AFTER EXPOSURE TO 2 ML. OF LABELED CLAY IN 1500 ML. OF SEA WATER.

Tissue	After 48 hrs.	After 72 hrs.
Whole animal	449	394
Cephalothorax	560	376
Abdomen	165	96
Exoskeleton	672	*

*This specimen ecdysed during the first 48 hours. The shed skin showed relatively high activity at 1944 counts per minute per gram.

Commercial and Biological Uses of the Maryland Soft Clam Dredge[1]

J. H. MANNING

Chesapeake Biological Laboratory,
Department of Research and Education, Solomons, Maryland

FILES OF THE UNITED STATES PATENT OFFICE contain drawings of dozens of mechanized shellfish harvesting devices, some more or less resembling the Maryland soft clam dredge. The Maryland gear, however, is unique in its demonstrated capability of harvesting sub-tidal stocks of deeply burrowing shellfish on a commercial basis. Developed in the early 1950's and patented by Mr. Fletcher Hanks of Oxford, it has been used in Maryland exclusively for digging soft shell clams (*Mya arenaria*), with a degree of success which has

[1]Contribution No. 131, Maryland Department of Research and Education, Solomons, Maryland.

enabled the State to assume a position of leadership in soft clam production. Concurrently with development of the soft clam fishery in the Chesapeake area, considerable investigative attention has been given to the biological effects of the gear and to its potentials as a collector or harvester of various species of shellfish and other bottom-dwelling invertebrates. It will be the purpose of this report, after describing the gear and its operation, to review some of the results of these investigations and evaluate the usefulness of the Maryland soft clam dredge to the commercial fisherman and the biologist.

The dredge is shown in operating position in Figure 1. Jets of water erode and loosen the bottom immediately in front of the scoop, which is forced ahead by propeller thrust. Shoes on the side of the scoop, which is hinged to the conveyor, travel on and parallel to the bottom, limiting the depth to which the dredge will dig. The shoes are not necessary when dredging level bottom, and many Maryland dredgers do not use them, depending rather upon adjustment of the forward suspension line to limit the depth of dredging. Dislodged bottom materials, washed into the conveyor, either fall through the interstices of the belt or are elevated to the surface, where the catch is culled. The dredge advances only as fast as the water jets loosen the soil, inasmuch as no available amount of propeller thrust can force the scoop through 16 to 18 inches of solid bottom.

The capability of harvesting sub-tidal stocks of soft clams is only one aspect of the gear's utility. Because the dredge can cover an area more than ten times as fast as a man using hand tools, populations of relatively low density can be exploited profitably. The economically limiting factor is, of course, operational expense, which is rather high. Studies recently undertaken by the Maryland Department of Research and Education indicate that fuel costs, which constitute more than 50 per cent of operational expense, can be reduced substantially by supplying the power for pump operation and propeller thrust from a single engine instead of the two engines now employed by commercial dredgers. This is accomplished by use of a controllable-pitch propeller which permits delivery of optimal thrust at any necessary pump speed. It is not unlikely that additional significant gains in efficiency of the dredge can be achieved by systematic study and application of engineering knowledge. Evolving mainly through process of trial and error, the gear has undergone only minor changes during seven years of commercial use in Maryland. Experimentation with different sizes and types

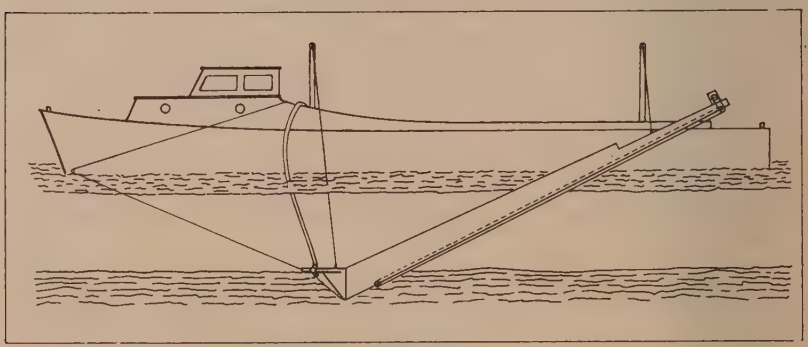


FIGURE 1. The Maryland soft-shell clam dredge.

of pumps, powering systems, conveyor belts, and jetting systems is expensive and time-consuming, and not apt to be undertaken by the individual dredge operator.

Maryland soft clam dredgers use centrifugal pumps exclusively, usually of end-suction, enclosed-impeller type with suction size ranging from 4 to 8 inches, seldom exceeding 6 inches. The pump is ordinarily driven by a 6- or 8-cylinder automobile engine capable of delivering power at several times the required rate. Pump discharge pressure of 30 to 50 pounds per square inch is normally employed by the commercial dredger, depending upon type of bottom and density of the clam population. Water is conveyed to the jet manifold through a flexible hose, usually of 4 inches diameter. The number and size of jets varies considerably; ten to fifteen pipes of one-half inch inside diameter are frequently used. Maryland law requires that the lateral jets be parallel to, and not farther apart than, the sides of the scoop, with the purpose of minimizing dislodgment of clams not directly in the path of the dredge. The rate at which the water jets erode the bottom is a function of velocity and volume of efflux, which vary interdependently with (1) pump discharge pressure and volume and (2) ratio of the cross-sectional area of the pump discharge line to the total cross-sectional area of the jet orifices. Capacity of a centrifugal pump varies directly with impeller width and in direct proportion to speed of rotation. Head varies directly with impeller diameter and in proportion to the square of the speed. The complexity of these relationships does not invite a desultory approach to the problem of selecting the right pump and designing the most efficient hydraulic system.

Conveyor belting used by commercial dredgers in Maryland, of 1-inch-square mesh, was not designed for the purpose and requires frequent replacement. The belt is usually driven by an air-cooled, 4-cycle gasoline engine of low horsepower. Power is transmitted by V-belt to a speed reducer, thence to the head pulley by chain-and-sprocket drive. Speed reduction is about 160 to 1, resulting in belt travel of 40 to 50 feet per minute. On some conveyors the drive pulley is lagged with rubber, but more commonly the pulley carries sprockets which engage the belt. Unless a torque limiter is included in the power transmission system (and usually one is not), overloading results in stalling the engine or tearing the belt, which does not have great tensile strength. A few dredgers have adopted electric or hydraulic powering of the conveyor, with gratifying results. The ability to vary rate of belt travel is a distinct advantage. In dredging sandy bottom relatively free of shell, stone, and debris, belt speed may be reduced to that of the boat, with resultant savings in belt wear. Where a high percentage of the bottom materials will not pass through the belt, as when very shelly bottom is dredged, overloading can be obviated by increasing belt speed. Hydraulic power transmission offers wide latitude in varying speed with constant torque, and torque limitation consistent with tensile strength of the belting is a simple matter.

Dredging rates with equipment now in use range ordinarily from 5 to 20 feet a minute. Higher rates are associated with sandy bottoms; lower rates, with predominantly clayey soils, which offer great resistance to erosion and cannot be dredged profitably unless clams are very abundant. Dredging is seldom attempted in sticky mud or fibrous peat bottoms, which are extremely difficult to dredge and seldom support dense populations of clams. Stony bottoms can be dredged more or less successfully by removing a section of the bottom of the

scoop, allowing the stones to fall through and pass beneath the dredge. Dense growths of rooted vegetation, especially the claspingleaf pondweed, *Potamogeton perfoliatus,* present major difficulties to the dredger. The uprooted plants tend to roll up into a ball and block the lower end of the conveyor, leading to accumulation of bottom materials and overloading of the belt.

The cost of dredging soft clams varies widely from place to place, day to day, and dredger to dredger. Per-acre fuel costs range from a minimum of about $30 for dredging sandy bottom to $60 or more for dredging in hard clay. The cost of fuel constitutes somewhat more than 50 per cent of the total operational expense, not including wages of crewmen.

In an earlier report (Manning, 1957) it was estimated, on the basis of economic factors then prevailing, that profitable operation of the dredge required a minimum population density of about 50 bushels of marketable clams per acre. On the basis of current economic factors and dredge performance data, the estimate remains unchanged as an approximation applicable to the areas of predominantly sandy bottom which support the greater part of Maryland's clam fishery. It should not be interpreted as meaning that discrete populations of 50 bushels per acre are commercially exploitable. This is the level below which, usually, density cannot profitably be reduced by the almost completely random method of harvesting commonly practiced.

It is of interest to compare the minimum density required to support a hand-tool fishery with the same net profit to the digger. Dickie and MacPhail (1957) state that the average rate of digging with clam hoes is 275 square feet (0.00631 acres) per hour with efficiency of about 60 per cent. Data of Dow et al. (1954) indicate that about 65 per cent of the marketable clams are taken undamaged from Maine flats by hand-tool diggers. The Maryland clam dredge can turn about 0.073 acres of sandy bottom per hour, on the average. Studies reported by Medcof (1958, 1960) and Dickie and MacPhail (1957) indicate that the Maryland dredge catches more than 95 per cent of the marketable clams in its path with less than 1 per cent breakage of the catch. Our observations agree closely. Thus the effective areal harvesting rate of the dredge is approximately eighteen times that of the clam hoe. Operational expense of the dredger is substantial, however, and that of the hand-tool digger is negligible. Fuel and maintenance expenses of dredging are time-rate factors; labor cost varies in direct proportion to the number of bushels of clams caught. When dredging sandy bottom with population density of 50 bushels per acre, the total operational cost will be from $5 to $6 per hour and the value of the catch about $10 per hour at the current price of $3 per bushel. A hand-tool digger receiving the same price would have to work where population density exceeded 400 bushels per acre to earn $4 to $5 per hour of digging.

The ability of the clam dredger to reduce populations of market-size clams to relatively low levels has caused some concern lest spawning stocks be reduced to inadequacy. This capability is offset in some degree by the relative innocuity of the dredge with respect to clams of sub-marketable size. In meticulous experiments reported by Medcof (1960) more than 90 per cent of the small clams displaced by the dredge were deposited on or shallowly buried in the soft soil of the track within 75 feet of their points of origin. Only about 7 per cent suffered shell damage, and apparently all undamaged clams re-burrowed. In contrast, hand-tool digging destroys, on the average, about 50 per cent of the juvenile population (Dow et al., 1954; Medcof, 1958). After seven

years of commercial dredging in Maryland, we have found no evidence of insufficient reproduction or replacement of harvested stocks. It should be noted, however, that in the five counties where dredging is permitted, not more than half the area within the ecological range of the soft shell clam and the operational range of the dredge is open to the dredgers. In addition, Maryland has substantial populations of clams beyond the range of the dredge, which is confined by legislatively imposed structural limitations to depths not exceeding 10 or 11 feet.

In Maryland, investigations have centered on the biological effects of soft clam dredging on tidewater resources in general. Early studies reported by Manning (1957) indicated that the effects were highly localized. Significant numbers of oysters were killed by excessive deposition of sediments within 25 feet of the periphery of an intensively dredged area, and enough sediment was deposited at a distance of 50 feet to jeopardize survival of oyster spat. No measurable deposition of sediment occurred at a distance of 100 feet. Rooted vegetation is virtually eradicated in the path of the dredge but otherwise unaffected. Revegetation requires greatly varying periods of time, depending chiefly upon the thoroughness with which an area is dredged and the degree of exposure to wave action. We have been unable through experimental or statistical approach to demonstrate any effect on distribution and abundance of blue crabs and fish. More recently attention has been focused on changes in physical and biotic structure of dredged bottoms and modifications to the dredging gear. These studies will be reported in 1960.

Personnel of the St. Andrews, New Brunswick, Biological Station of the Fisheries Research Board of Canada have conducted numerous and characteristically excellent experiments with the Maryland-type clam dredge since 1955. Especially pertinent to the intent of this report are their studies of the dredge as a harvester of species of shellfish other than *Mya arenaria*. By adjustment of the shoes and water jets they have adapted the dredge to the harvesting of bar clams and quahaugs with impressive results. Medcof (1958) estimated that production of bar clams, then harvested with forks, could be quadrupled by use of the dredge. The modified dredge fishes quahaugs 30 to 40 times faster than they can be taken with rakes, and 80 to 100 per cent faster than they can be harvested with hydraulic or rocker dredges. Equipped with rubber-tired wheels and with the jets directed parallel to the bottom, the dredge harvests oysters at a phenomenal rate without disturbing bottom soil or plants.[2]

Although reported investigations of the use and effects of the Maryland-type clam dredge have been confined to Canada and Maryland, its use for culture and harvesting of shellfish has not been so restricted. In Rhode Island the dredge has been used successfully to remove quahaugs from polluted areas for transplantation.[3] It has been employed commercially in Virginia for harvesting soft shell clams. Somewhat modified and constructed to larger scale, the dredge is now used successfully in the Long Island quahaug fishery. It has undergone apparently successful trials in the State of Washington (McLeod, 1958), and has been used for exploratory fishing in at least two other states where regulations prohibit commercial use of mechanical or hydraulic dredges.

---

[2]Personal communications, J. S. MacPhail, J. C. Medcof, St. Andrews, N. B., Biological Station, Fisheries Research Board of Canada.

[3]Personal communication, Robert Campbell, Div. of Fish and Game, Dept. of Agriculture and Conservation, State of Rhode Island.

The Maryland clam dredge, modified for surface fishing or shallow dredging, has intriguing potentials in shellfish culture. Medcof (1958) mentions its capacity for taking up oyster shells and starfish in an oyster-growing area devastated by the epidemic disease prevalent in New Brunswick. While surveying clam populations in Maryland we have dredged areas where buried oyster shells could be recovered in enormous numbers. We have estimated rate of catch in one area as exceeding 500 bushels per hour, at a cost, not including labor, of about one-half cent per bushel of thoroughly washed shells.

The possibility of employing the dredge in starfish control should be explored. Modified for surface fishing, a dredge with scoop width of 3 feet undoubtedly could cover level bottom at a rate of one acre per hour, and the catch could be subjected to chemical treatment and returned to the water in a continuous, possibly automatic process.

With conveyor belting of small mesh size, the dredge may be useful also in oyster drill control. We customarily use woven wire belting of 3/8-inch mesh for exploratory survey of clam bottoms, and it is not unlikely that belts of smaller mesh could be used for surface fishing or shallow dredging.

The catch of bloodworms (*Glycera dibranchiata*) incidental to clam dredging in Maryland, where the bloodworm population is sparse, suggests that the gear might be employed to great advantage in areas having commercial populations of bloodworms and sandworms. In fact, the demonstrated versatility of the Maryland-type clam dredge suggests that it may be adaptable to the harvesting of a wide variety of aquatic resources, including crabs and other crustaceans, sponges, seaweeds, and possibly some species of finfish. Motility *per se* does not exclude a species from capture. Several species of fish seem to be attracted to, rather than repelled by, the dredge, presumably because of the quantities of food which become available as the bottom is eroded by the jets. Among local fishes frequently caught are hog chokers (*Trinectes maculatus*), eels (*Anguilla rostrata*), spot (*Leiostomus xanthurus*), and white perch (*Roccus americana*). Blue crabs (*Callinectes sapidus*) and grass prawns (*Palaeomonetes vulgaris*) are sometimes taken in considerable numbers.

To the biologist, the Maryland clam dredge is an invaluable tool. Within its depth limitation, it offers a means of quantitative sampling of almost any type of bottom with speed, precision, and the convenience of a screened and washed sample. Even the most fragile organisms, such as the trumpet worm (*Cistenides gouldii*), are seldom damaged.

The technique of using the dredge as a quantitative sampling gear is simple but requires care and a little practice. With the dredge in operating position, pump speed and propeller thrust are reduced until the dredge is progressing steadily but very slowly. A pole is then thrust vertically into the bottom alongside the boat, a short distance ahead of the first of two marks on the rail. Collection of material from the conveyor belt begins when the pole is abreast of the first mark and ends when the pole comes abreast of the second mark. Sample size is a function of scoop width and linear progress of the dredge. We have found 20-square-foot samples generally convenient and, having a dredge with scoop width of 30 inches, use marks 8 feet apart. Depending upon the purpose of the sampling, material may be selected from the belt or collected *in toto* as it falls over the after end of the conveyor. We have found that collection in baskets held under the end of the conveyor often results in breakage of the more fragile animals. For collection of whole samples we prefer

towing a float with wire mesh bottom under the end of the conveyor, deep enough that water cushions the impact of falling material.

This method of sampling requires that rate of travel of the conveyor belt exceed rate of linear progress of the dredge, and that these rates remain constant for a short time before and during the sampling. The dredge must, of course, travel in a straight line, a requirement which is easily met by steering so that the rail of the boat is kept a constant distance from the vertically-driven pole. If the rail is not essentially parallel to the keel-line of the boat, a "false rail" can be used as a reference plane.

Inasmuch as the dredge when carefully operated is virtually 100 per cent efficient, highly quantitative samples are obtainable by the method described. No other gear of which we have knowledge has equal utility in shoal-water surveys of commercial shellfish or in studies or distribution, abundance, and ecologic relationships of the littoral macro-benthos. To view the panorama of bottom communities passing on the conveyor belt is a unique and rewarding experience, one that challenges the biologist to make greater and better use of this remarkable machine, the Maryland clam dredge.

LITERATURE CITED

Dickie, L. M. and J. S. MacPhail
1957. An experimental mechanical shellfish-digger. Progress Reports of the Atlantic Coast Stations of the Fish. Res. Bd. of Canada, No. 66, pp. 3-9. September.

Dow, R. L., D. E. Wallace and L. N. Taxiarchis
1954. Clam (*Mya arenaria*) breakage in Maine. Dept. of Sea & Shore Fish., Augusta, Maine. Research Bull. No. 15. January.

Manning, J. H.
1957. The Maryland soft shell clam industry and its effects on tidewater resources. Md. Dept. Research & Educ., Resource Study Rept. No. 11. January.

McLeod, K.
1958. Clam farming. Fisheries, Fish Farming, Fisheries Management. Wash. State Dept. of Fish., Seattle, Wash. pp. 53-60.

Medcof, J. C.
1958. Mechanized gear for shellfish harvesting and shellfish culture. Ex. MS Rep. Series (Biological) 644, Fish. Res. Bd. Canada, Biol. Sta., St. Andrews, N.B. 12 pp., 2 tables.
1960. Effect of escalator harvester on under-size soft-shell clams. Proc. Nat. Shellfish. Assoc. for 1959. In press. 9 pp., 3 tables.

The Biological and Economic Problems in Marine Fisheries Management[1]

Richard Van Cleve

University of Washington, Seattle, Washington

In the Northwest we have, in spite of the Japanese, tended to view our fisheries management problems as of sole concern to ourselves and possibly Canada. Our complacency has recently been rudely shaken by the appearance of Russian trawlers off Alaska's coast.

[1]Contribution No. 79, College of Fisheries, University of Washington.

Although not much publicized, especially as to the activities of the scientists, the International North Pacific Fisheries Commission is itself evidence of the growing international flavor of the management of our high seas fisheries. This has been further emphasized by the Geneva conference on the Law of the Sea called by the United Nations in the spring of 1958.

Whether we like it or not the management of our high seas fisheries cannot be viewed as a matter of our concern alone. The nations of the world have declared their interest in all high seas fisheries and this interest may be expected to affect our entire approach to problems of management of these fisheries. An examination of recent events in which the international aspects of high seas fisheries management have been discussed is therefore appropriate.

The Geneva Conference on Laws of the Sea

The 1958 Geneva conference of the United Nations on the Law of the Sea climaxed a number of years of study by representatives of member states to develop a code of law for the sea. The results of this conference were expressed in four proposed treaties covering various aspects of maritime law, which are now being considered for approval by the different nations. If approved, they will constitute a code of law which will govern the activities of man on the seas and incidentally will be the basis for fisheries regulations beyond territorial limits.

Since they represent a series of compromises the provisions of the treaties are not very specific on many points. For example, the breadth of the territorial seas is defined in Article 6 of the proposed convention on the "Territorial Sea and Contiguous Zone" (Document A/Conf. 13/L.52) as follows: "The outer limit of the territorial sea is the line every point of which is at a distance from the nearest point of the baseline equal to the breadth of the territorial sea." Apparently no agreement could be reached as to whether the territorial limits should be three miles or two hundred miles in breadth. Since the United States has advocated three miles for some years, we cannot expect these limits to be extended much farther out to sea in the near future, although a suggestion of six miles for territorial limits, plus an additional six miles for the limits of exclusive rights for fisheries, is rumored to have been proposed and to have received considerable support.[2]

The effect of any reasonable territorial limit upon fisheries regulation may be appreciated by consideration of other provisions regarding fisheries which are included in Article 2 of the Convention of the High Seas (Document A/Conf. 13/L.53). This article provides as follows: "The high seas being open to all nations, no State may validly purport to subject any part of them to its sovereignty. Freedom of the high seas is exercised under the conditions laid down by these articles and by the other rules of international law. It comprises, *inter alia,* both for coastal and non-coastal States:

1. Freedom of navigation;
2. Freedom of fishing;
3. Freedom to lay submarine cables and pipelines;
4. Freedom to fly over the high seas.

"These freedoms, and others which are recognized by the general principles of international law, shall be exercised by all States with reasonable regard to the interests of other States in their exercise of the freedom of the high seas."

[2]This proposal was rejected at the second U. N. Conference on the law of the sea held in April, 1960, so that territorial limits remain a subject of controversy.

Fisheries conservation is covered more extensively in the "Convention on Fishing and Conservation of the Living Resources of the High Seas" (Document A/Conf. 13/L.54). This proposal again insures the right of all nations to fish the high seas, "subject (a) to their treaty obligations, (b) to the interests and rights of coastal states as provided for in this Convention, and (c) to the provisions" . . . of this convention. Later articles provide that states participating in a fishery shall agree to conserve it, or if they cannot agree the matter is to be submitted to arbitration. This assumes that at least one of them wants to conserve it.

The rights of coastal states are defined in Articles 6 and 7 of this same proposed treaty. These recognize the special interests of a coastal state in maintaining the productivity of fisheries off its coast. They declare the right of a coastal state to take part on an equal footing in research and in regulation of its coastal fisheries, regardless of whether it participates in those fisheries, and also the right to initiate conservation regulations to protect those fisheries. It is important to note that the proposed treaty states that these measures are to be valid for other states only if the following requirements are fulfilled: (a) that there is a need for urgent application of conservation measures in the light of the existing knowledge of the fishery; (b) that such measures do not discriminate in form or in fact against foreign fishermen.

These conditions are also to govern the deliberations of any special commission set up, as provided in the convention, to arbitrate disputes concerning fisheries conservation. There is no mention of the principle of abstention in any of the proposed treaties, although the principle was proposed by the committee on fisheries and missed approval by only a narrow margin of votes. The conference also rejected the resolution adopted by the committee on High Seas Fishing and Conservation of Living Resources, (A/Conf. 13/L.21 Annex), which "commended the abstention procedure to States for utilization where appropriate . . ."

Several conclusions may be drawn from the results of this conference.

The treaties formulated by this conference represent the results of careful study by the International Law Commission, appointed by the United Nations for this purpose. They include all points of international law of the sea upon which the nations of the world could agree at the time of the convention, and therefore may be viewed as the future basic law of the sea whether or not the treaties are accepted formally by all nations. These treaties should be of special interest to fisheries conservationists as well as to the fishing industry.

The right of any nation in the world to share in any fisheries up to the present 3-mile limit which we currently claim is recognized by most nations in the world. It is well for us to realize this means that if we do not develop our fisheries, others will certainly develop them. They can also promulgate regulations for these fisheries if necessary, and if their regulations are based upon appropriate scientific findings they will probably be recognized internationally.

Only those who participated in the conference will know what was behind the choice of words used to formulate these proposed laws to govern fishing on the high seas. Since I am not a lawyer I cannot say how they might be interpreted in court or by any arbitrators who might some day be appointed under these regulations to settle disputes that may arise over these fisheries. Viewing them as a fisheries biologist they seem to recognize only the possible need for regulation without stating why such regulation might be needed "urgently."

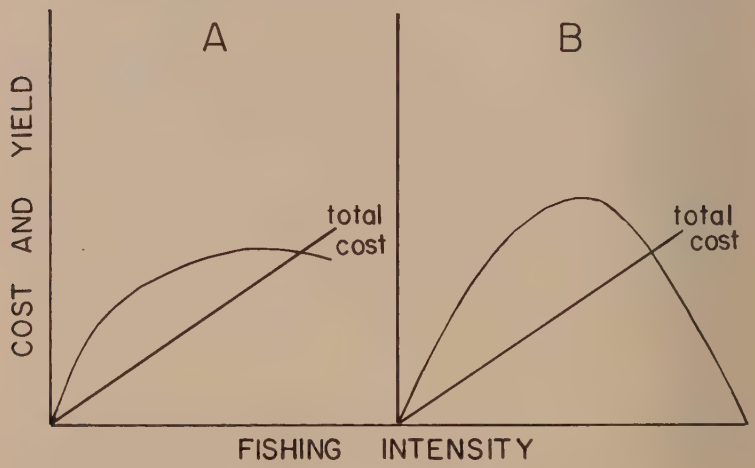
All of the background statements and documents upon which this agreement is based are specific on this point, however, and recognize that the "Principal objective of conservation of the living resources of the seas is to obtain the optimum sustainable yield so as to secure a maximum supply of food and other marine products." (Paragraph 18 Section II, Rept. Int. Tech. Conf. Cons. Advisory Res. Sea UNA/Conf., 10/5 Rev. 2, July, 1955.) This is called elsewhere the "maximum sustainable yield" (UN 392 A/CN. 4/Ser. A/1956).

The discussions which were developed at the Conference on the Biological and Economic Aspects of Fisheries Management, held at the University of Washington in February, 1959, indicate that this objective should be qualified by economic considerations. Moreover according to Beverton and Holt (1957) the existence of a unique maximum sustainable yield may be doubtful. These authors have developed a theory of the reaction of a stock of fish to a fishery, which results in the yield rising continuously and asymptotically as the fishing intensity is increased and as the minimum size or age limit of fish taken is raised.

Figure A must be viewed as 3 dimensional and the relationship has been given the name of the eumetric fishing curve. This may be contrasted with Figure B the curve drawn by Schaefer (1959) which indicates that total yield will decrease from some maximum as the fishing intensity is increased without limit.

In either case, however, the authors indicate that as the fishing intensity increases the total cost of landing the fish must increase. The simplest possible concept is that this increase will follow a straight line. Eventually the cost curve and the yield or value curve intersect and the net profit or "rent" from fishing disappears at this point.

If the theory of eumetric fishing is valid, there will be no maximum level of total yield that is unique for the fish population in question. There is a maximum net economic yield however which may be defined as that level of fishing and of the minimum size limit at which the eumetric curve lies farthest above the



FIGURES A AND B. Relationship of sustainable catch and total cost to fishing intensity. Curve A is eumetric fishing curve.

total cost curve. Under constant conditions of production of fish (growth, natural mortality, etc.) and with a constant relationship of cost to fishing intensity this point may be defined, provided sufficient information is available concerning the biology of the fish population, the relationship of the fishery to the population, and the economics of the fishery.

The "eumetric fishing curve" derived by Beverton and Holt requires extrapolation far beyond any population levels that have been observed and includes imperfect approximations of the effects of great increases in population density which do not correspond with conditions encountered so far in dense populations of fish. It is difficult therefore to acknowledge its validity, and Schaefer's approximation seems to correspond more nearly with present knowledge of fish as well as other types of populations. According to this theory the yield will finally decrease as fishing intensity F (Figure B) is increased so that the intersection of cost and value curves occurs at a much lower level of fishing than it would in Beverton and Holt's model. As long as the cost curve has a positive slope the level of maximum economic yield will occur at a fishing intensity lower than that which will produce maximum yield.

It is apparent then, whichever of these two theories is accepted, that maximum economic yield will always occur at a fishing intensity below that at which maximum yield can be obtained (this is at $F = \infty$ in Beverton and Holt's theory). Moreover as the cost per unit of fishing effort increases, i.e., the steeper the cost curve rises, the point of maximum economic yield will lie farther to the left of the level of maximum biological yield. The biological and economic maxima will lie closer together as the cost per unit of fishing decreases. They will only coincide if costs are zero.

Let us examine the relationship this theory has to the methods of handling high seas fisheries proposed by the UN conference cited above. It is necessary to combine these proposals with currently accepted methods of regulation as enforced by the International Halibut or Salmon Commissions, by the Fish and Wildlife Service or by the various States. These regulations generally limit total catch but do not limit the number of boats or the number of separate units of gear which may be used to take that catch, although several attempts to accomplish this purpose have been made, for example in Chesapeake Bay and in Alaska. In other words accepted conservation regulations are aimed at attaining the "maximum sustainable yield" however that may be defined. Under these circumstances, with no limit on amount of gear which may be applied, the number of active units of effort utilized to capture a limited total yield will be increased until the net income or profit is reduced to that level where the number of fishermen leaving the fishery for easier or more profitable pursuits will be balanced by the number of new ones entering, or amount of gear leaving equals amount entering. We will assume that the total yield or catch, and the manner in which it is taken, are regulated "properly" so as to obtain the maximum sustainable yield. We can assume that with regulation for the sole purpose of obtaining the greatest yield in weight of fish, (if the level of maximum yield can be found) and the catch fixed at that point by law, the cost curve will rise vertically as the number of boats and amount of gear increases until the point of intersection of cost and value curves will lie at the point of maximum catch.

Whether or not this situation is satisfactory economically, it corresponds with conditions as they exist at present.

What would happen then if fishermen of another nation decided to enter this fishery? Under the treaties proposed by the Geneva Conference, the best that could be hoped for would be that the new entry would conform with established catch limits and with regulations set up by those already regulating the fishery for taking that catch and would even conclude a special treaty binding themselves to follow those regulations in perpetuity! In the meantime, however, the number of fishing boats as well as units of gear in use has been increased beyond the stable level that has provided only the minimum "opportunity returns" which had kept the original fleet stablized. The original fleet, therefore, would face the necessity of either reducing its size by eliminating fishermen, boats, and gear from the fishery, or of accepting a reduced income. Since we originally supposed that the fishery was stable at a point where net income was just sufficient to attract the same numbers of fishermen into the fleet as were leaving for more lucrative or easier pursuits, we could assume that a decrease in net income, such as would result from the entrance of another nation's fishermen into the fishery, would cause a reduction in the number of fishermen, in the number of boats and in the amount of gear operated by the original nation. These fishermen would then be forced out of their chosen trade and would have to find employment elsewhere. Meanwhile, the catch formerly available directly to the original country would either be directed elsewhere or would have to be purchased from foreign fishermen. Aside from implications regarding foreign trade balances or food supplies, if the original fleet was operating at a level of maximum efficiency, nothing will have been gained by the world as a whole from the substitution of one group of fishermen for another; and in the case of some states which are economically vitally dependent upon their fisheries, such a displacement of fishermen would result in unnecessary hardship. Certainly nothing has been added to the world's supply of food.

The case described above is a very special one which probably the halibut fishery of the northeastern Pacific alone approximates. It is instructive to examine the effects of entrance of a new nation possessing a more efficient fleet, i.e., lower cost per unit of fishing effort, into an unregulated fishery. Unless the original and less efficient fleet were protected by tariffs or subsidies, the more efficient one should have no trouble in capturing the fishery, just as a more efficient type of gear will supplant a less efficient one unless the latter is artificially protected by regulation, as is presently true in the Alaska salmon fishery.

Many other possible situations may be described for which examples could be found in the world's fisheries, but time does not permit examination of more of them here. The burden of all such conceivable sets of events would seem to be that in unregulated fisheries under proposed international law the more efficient fleet would supplant the less efficient one by reducing the level of abundance and catch to levels at which the latter could no longer survive. In the case of regulated fisheries, under existing management practices, assuming the catch is stabilized at the maximum a stock of fish is capable of producing, nothing will be gained economically nor will any additional food be produced by the entrance of another nation into such a fishery, provided the original fishing fleet is operating at or near maximum efficiency. No consideration has been given here to any claims the original fishermen may feel they have to a fishery which they have conserved and developed to its level of maximum yield.

Effect of Regulation to Obtain Maximum Economic Yield

If our concepts of fisheries management should be altered to permit substitution of the objective of maximum economic yield for maximum biological yield, it is at once apparent that the proposed international law for high seas fishing is completely inadequate. In fact, it is inadequate for any type of conservation since, theoretically, any nation desirous of entering a regulated fishery could force its way in by obscuring true issues or refusing to recognize the validity of any case that might be presented in the interests of conservation. Marine fisheries biology is so complex and until the last few years has been supported by acceptable data only in a few specific cases. As a result definite answers to many important questions have not yet been found. Decisions concerning the need for conservation are easily confused even by sincere biologists who, because of complicated situations, can arrive at widely opposite conclusions from the same data. The situation would be greatly complicated by an attempt to maximize the economic yield. This could only be achieved by complete regulation of the number of boats, as well as the number of units of gear which are permitted to enter the fishery. It must even be assumed that regulations would have to be designed to force, or at least encourage, continued modernization of techniques to maintain efficiency and minimum costs.

Such control would be comparable with that exercised through ownership and could not be accomplished if anyone who might wish could inject a new fleet of boats into such a fishery. Successful economic control could only be accomplished under an arrangement which would reserve all rights in a fishery to those operating it.

How this is to be done within existing concepts of fish conservation is an unsolved mystery with clues to possible solutions furnished, for example, by accepted methods of handling public grazing lands by the U. S. Forest Service, but with the added complication of location of the high seas fisheries in a sort of no man's land. The scope of the problem would be reduced to manageable proportion by international acceptance of the principle of abstention as the basis for handling high seas fisheries conservation.

The principle of absention was first formulated in the "International Convention for the High Seas Fisheries of the North Pacific Ocean," a treaty between Canada, Japan and the United States, signed in Tokyo in 1952.

The principle provides in brief that if any nation has developed and conserved a fishery it has certain rights to that fishery. These rights are retained as long as it can show that its use of the fishery is scientifically controlled, and that it is obtaining the maximum yield the stock is capable of producing. The joker in this deck is the requirement that to obtain abstention, at present, the nation in possession must prove to the satisfaction of any other country which might wish to enter the fishery that the fishery complies in all the respects with the requirements for abstention. It would seem as though some more objective way of reaching such a decision could be provided than that of pitting one nation against another in this manner. Perhaps the method of arbitration proposed by the fisheries committee at the Geneva Convention would provide objectivity.

At the various meetings of the International Law Commission the abstention principle was refined and finally presented in a form only slightly altered from that provided in the International North Pacific Fisheries Treaty. Since it was rejected by the Geneva conference, it would seem that we are discussing a lost

cause except for the North Pacific treaty. But the margin of loss at Geneva was small, and it still appears to be the most logical solution to the still unsolved problems of conservation of high seas fisheries.

At present, it is looked upon solely as a method of insuring continued conservation of fisheries. It may be viewed literally as a sort of reward to a nation and its fishermen for a competent job of fisheries management. By implication this recognizes the economic value of a fleet and its equipment, but is still a far cry from recognizing the development of maximum economic yield as a valid objective of fisheries management. Acceptance of this objective by all nations presents a number of complications that seem to make it improbable that we shall soon see it established on an international scale.

Whatever develops in the law of the high seas as it pertains to fishing, and to fish conservation, a common thread of thought may be followed through all of the proposals, including those that came out of the Geneva conference. This states firmly that the management of the high seas fisheries is going to be based upon scientific research of a quality acceptable to all nations. The high standards that must be met are evident in the deliberations of the International North Pacific Fisheries Commission and in the discussions of the participating scientists. The Commission is charged with determining whether various stocks of fish can comply with the requirements for abstention. Scientific justifications have been subjected to the searching criticism of the most competent fisheries biologists available to the three participating nations. The similarity of requirements for regulation by Coastal states, or others of high seas fisheries provided in the fisheries regulations proposed by the United Nations, indicates that in the future any such regulations will be subjected to similar scrutiny.

It appears that fisheries biology has come of age and that the responsibility for formulating programs of management of high seas fisheries will in the future fall on the biologists' shoulders. It is only sensible that this should be true.

A recent suggestion that we face the need to divide the ocean into zones, which will be reserved for certain nations to exploit may be a view of the future. This is not a matter that can be proposed lightly as may be concluded from the unforeseen difficulties that have haunted our Pacific tuna fisheries ever since the so-called Truman Doctrine of conservation zones was proclaimed in September 1945. Possibly the claims of several South American countries to territorial limits of 200 miles would have developed alone, but these claims were stimulated to an unknown degree by the proclamation.

Finally conservation to be effective must deal with whole stocks of fish and conservation boundaries which ignore the biological boundaries of such stocks will be futile.

LITERATURE CITED

Breverton, R. J. H. and S. J. Holt
1957. On the Dynamics of Exploited Fish Populations. Ministry of Agriculture, Fisheries and Food, Fish. Invest., London, Ser. II, vol. 19, 533 pp.

Schaefer, Milner B.
1959. Biological and Economic Aspects of the Management of Commercial Marine Fisheries. Trans. Am. Fish. Soc., vol. 88, no. 2, pp. 100-104.

Ecological Diagnosis of a Species and the Problem of Biological Constants[1]

G. L. Kesteven and H. Rosa, Jr.
Biology Branch, Fisheries Division, Food and Agriculture Organization of the United Nations, Rome

Abstract

Considers the information content of a standard systematic diagnosis of a species, and after suggesting that such a diagnosis is deficient with regard to the properties of a species as unit of ecological complexes, surveys the information required for applied science. The need for comparative ecological research is considered, especially with regard to the possibility of identifying "biological constants." The systematic and evolutionary significance of these aspects is discussed.

In a paper presented to the International Colloquium on the comparative biology of marine species studied in different districts of the area of distribution (Roscoff, France June-July 1956) Kinne (1958) presented certain ideas on the ecological diagnosis of a species which seemed to us to have special relevance to the problem of general orientation of current research in marine biology. Kinne (1958) states: "We must know the *potentialities of the species as given by its specific physiological and structural constitution* freed from any interspecific ties." This was elaborated as follows: "If we wish to advance from descriptive to causal ecology we need, in addition to a systematic diagnosis, an *ecological diagnosis of each species*. This ecological diagnosis must characterize in a few words the potentialities of a species as well as its specific demands and abilities (biological), physiological and genetical definition of a species."

These ideas had a close affinity with ideas on the same subject which the authors had been developing as part of their work and which were described by them (Kesteven, Rosa and Holt, 1958) at the same meeting. After describing briefly the objectives and methods of FAO's work with regard to living aquatic resources, they said that "The intention is . . . to accumulate information in summarized form to help make it possible to predict the distribution, abundance and other characteristics of the stocks of a given species under defined circumstances," and that "whilst fisheries biology aims to measure the values of certain gross phenotypic attributes displayed by the populations of species of economic importance, it is coming to be recognized that, for the purposes of the program for which these investigations are prosecuted, it will be necessary to consider also the mechanisms of which these phenotypic attributes are expressed and the fact that those mechanisms include genetic as well as environmental elements."[2]

Since that meeting, this work has been continued along the lines indicated and in particular drafts of "synopses" have been prepared for Rastrelliger, Hilsa, Tinca, Whales and Trichiuroidei (see Rosa, 1957, 1958) in which experimenting has been done in the reduction of published data on aquatic organisms and in the presentation of these data in summarized form. This, which has proved to be a by no means simple task, is one the authors believe is related to the important advance to be made in biology suggested by Kinne. Presented

[1]This paper was presented during the Eleventh Annual Session of the Gulf and Caribbean Fisheries Institute at Miami Beach in 1958.
[2]A small change in wording has been made in this quotation to clarify its meaning.

here is a brief account of certain of the authors' thoughts on this matter in the hope that discussion of them will bring out suggestions.

The Species Concept, and the Systematic Diagnosis

The authors do not propose to enter the lists to joust at established formulations of the species concept, but are obliged to make their own position in this matter clear since, as Kinne (1958) says in the paper referred to, "The species is not only the central point, but also the fundamental unit and measure of ecology." Basically we are with Huxley (1942) who states that "species are biological units, marked off from related units by partial or complete discontinuities" and we add to this his earlier statement (Huxley, 1940) "that they are groups which (a) have a geographical distribution-area; (b) are self-perpetuating as groups; (c) are morphologically (or in rare cases only physiologically) distinguishable from other related groups; and (d) normally do not interbreed with related groups, in most cases showing partial or total infertility on crossing with them (though neither the lack of crossing or of fertility is universal)."

In his 1942 work, Huxley quoted with approval Tate Regan's definition: "A species is a community or a number of related communities, whose distinctive morphological characters are, in the opinion of a competent systematist, sufficiently definite to entitle it, or them to a specific name."[3]

In this definition, even more than in Huxley's, the emphasis is on morphology, and rightly so for the purposes of classification. But the majority of taxonomists have held that their task was "that of detecting evolution at work" and some of them "proclaim the phylogenetic basis of natural classification" (Huxley, 1940). Other workers have held a different view and the following summing up by Huxley (1940) seems to put the issue squarely: "In the first place we may admit that taxonomic classification actually arrives at its results by evaluating resemblance and difference in the largest possible number of characters, and not by means of phylogeny, which can only be subsequently deduced, and is only measureable, if at all, in terms of the characters used in taxonomic evaluation. In the second place, however, it is certainly true that it can have what I may call a phylogenetic background, in that it can most often be interpreted phylogenetically; and, further, that such a phylogenetic interpretation may sometimes suggest an improved taxonomy. But it must, finally, also be admitted that there are certain cases where taxonomy does *not* have a phylogenetic basis."

This debate is not entered on the phylogenetic value of a natural classification. Our interest is in the discontinuities of the first part of the Huxley definition quoted above, and the dynamic characteristics of a species. However, it is suggested (and shown below) that not only is it necessary from the ecologist's point of view to add an account of the dynamic characteristics of a species to its taxonomic diagnosis, but that to do so will validly supplement the standard diagnoses in purely systematic sense, and contribute to analysis of the evolutionary processes.

It would, of course, be a foolishly extreme position to take to assert that each

[3]Despite Norman's (1948) elucidation "By the term community is meant a collection of individuals such as occurs in nature, with similar habits, which live together in a certain area and breed freely with one another" it is supposed that the term community should be replaced by a term such as population, considering the use today of the term "community" as referring to an assemblage of species.

systematic diagnosis is little more than the detailed entry on the identity card of individuals to which is applied the name lying above that diagnosis, but it is true that what is wanted is knowledge of the community function of those individuals.

In order to emphasize the point, Norman (1934) is quoted in full, a standard systematic diagnosis of a species, choosing for this purpose a species of considerable economic importance, the plaice, *Pleuronectes platessa.*

"Depth of body 1 1/2 to 2 1/4 in the length, length of head 3 to 3 7/8. Upper profile of head distinctly concave, Snout (in adults) longer than eye, diameter of which is 4 (young) to 8 length of head; lower eye a little in advance of upper; interorbital ridge low, narrow, naked or with a few embedded scales; a bony prominence in front of lower eye and often a trace of another before upper eye; a row of 4 to 7 irregular bony prominences extending from behind the eyes to commencement of lateral line, their bases sometimes connected by a low keel. Maxillary extending to below anterior part of eye, length on ocular side 4 1/4 to 4 3/4, on blind side 3 2/3 to 4 in that of head; lower jaw a little project, 2 1/2 to 2 3/4 in head. Dental formula $\frac{0-6+18-32}{2-7+18-35}$ 6 to 9 gill rakers on lower part of anterior arch; lower pharyngeals broader, width 2 3/4 to 3 1/2 in length, massive, approximated for more than half their length, their inner edges angular; each with 3 rows of large, obtuse, often flat, molariform teeth, arranged close together along the inner, outer and posterior edges of the pharyngeal bone, those of the inner row being larger than the remainder; sometimes 1 to 3 small teeth in the space between the rows. Scales mostly cycloid, but often more or less spinulate in the male; occasionally a few spinulate scales present in the female; 88 to 115 scales in a longitudinal series above lateral line; 85 to 102 pores in lateral line. Dorsal 65-70; origin above or a little in front of the middle of eye; middle rays frequently with a series of embedded scales on ocular side; highest rays about 1/2 length of head. Anal 48-59. Pectoral of ocular side with 9-13 rays (3 to 9 branched), length 2 to 3 in that of head. Pelvics with 6 (occasionally 7) rays. Caudal with 19 to 21 rays (12 to 15 branched), rounded or double-truncate; caudal peduncle generally deeper than long. 2 or 3 rather short pyloric appendages and one smaller appendage farther down the intestine. Vertebrae 42 to 43 (13 + 29 — 30). Brownish or greyish, with large, rounded, red or orange (often becoming white in spirit) spots sometimes margined with brown, scattered over the body; a series of similar spots along dorsal and anal fins, and frequently 2 or 3 at base of caudal. Distribution—Coasts of northwestern Europe, from the White Sea to the Gulf of Cadiz; Iceland. Apparently entering the western Mediterranean at times. Fage (1907) records the plaice from the Balearic Islands. 'Said to attain to a length of about 3 feet.' "

Physiological and Ecological Deductions to be Made From a Systematic Diagnosis

Obviously a description such as that above bears an intense functional connotation, some aspects of which are discussed in some taxonomic papers. But the point is that the functional connotation is not normally regarded as being a significant and essential part of a systematic diagnosis. There are, however, two intellectual processes operating to withhold this information on function from the systematic diagnosis. The first is that discussed by Cain and Harrison

(1958) under the title "An Analysis of the Taxonomist's Judgment of Affinity" and by Woodger (1945) in his discussion "On Biological Transformations." "It is customary to say of two forms that they are identical as far as is known *except* in the characters, w, x, y, etc. It is then unnecessary to measure thousands of characters in which these two are indeed for the purposes of this investigation identical." (Cain and Harrison ibid.). This is indeed the customary procedure in taxonomy: one assumes that if he indicates that a particular organism is a bony fish he need not also say that it has a backbone, gills and so forth. This means that only the essential *distinguishing* features are reported, which would not be so bad if it were not that it leads to more assumptions of similarity at deep morphological level than in truth are permissible; and this process is augmented by the second, referred to by Cain and Harrison (loc. cit.) as functional and ecological correlates. It is assumed that function, as a character, is itself a correlate of the structural element by which it is subserved, an assumption which at least may omit a great deal of the story. Thus, one assumes that possession of fins signifies ability to swim, which it generally does, but other abilities also are exercised through use of fins, and Tinbergen, Baerends and others have shown much significant specificity in the use of fins as elements of particular behavior patterns (see especially Baerends and Baerends-van Roon 1950).

Perhaps at this point the authors should emphasize that they are not in any sense suggesting that the judgment of any taxonomist is being challenged on the validity of the characters chosen to establish discrimination for the purposes of classification; nor, as said earlier, do they enter the discussion of the phylogenetic interpretation to be placed on displayed differences and similarities. What is being said is that the systematic diagnosis fails to give, as it very well could, information concerning the *dynamic* characteristics of the organism. And if the taxonomist should retort, as well he might, that "it isn't meant to," we must observe, with Kinne, that another diagnosis is needed. But at the same time it is ventured that perhaps the taxonomist is missing much that is significant; and the idea is developed below that, since after all the chief characteristic of living things is that they are alive and dynamic, the elements of that dynamism, in terms of biochemistry, physiology, behavior and synecology might perhaps be real specific characters. After all, no motorist would buy a car simply on a tabulation of certain of its structural characteristics (body length and height, number and dimensions of cylinders, etc.) even if he would be prepared to assume that it would have wheels, brakes and so forth; he is in fact more interested in performance indexes, attainable speed, rate of acceleration, fuel consumption, compression ratio, road holding characteristics and so forth.

Before continuing this line of thought, however, it is desirable to consider further the information conveyed explicitly and implicitly by current systematic diagnoses. Whilst Myr (1942) has said that the number of characters considered in a diagnosis is limited only by the patience of the investigator, diagnosis of fish species generally follow a pattern, similar to that of the plaice description quoted above. They generally comprise descriptions of body form by ratios of various measurements to, generally, total length of structural features of the head with relative proportion of eye, and of features of mouth and gill apparatus, scales, fins, vertebrae, coloration. It is our view that this information could be presented, in the taxonomist's own terminology, in a way

to be even more significant for the broader purposes we have in mind. Thus, in the case of body form there is an established terminology (anguilliform, depressiform, disciform, globiform, etc.) which at least more fully if not also more accurately describes the overall shape of the fish.[4] In the instance quoted above, a statement: "disciform (depth of body 1½ to 2¼ in length)" is more informative than the statement in the quotation itself. It is unnecessary here to recapitulate the results of workers such as Houssay (1912) and Breder (1926) although these would be the sources from which informative diagnoses, with regard to body shape, would be constructed. Similarly, mouth shape, dentition, fins (size, shape etc.), alimentary canal and coloration, have functional and/or ecological significance that could be succinctly indicated and which, if included, would add greatly to the information conveyed by the diagnosis.

Isolating Mechanisms and the "Ecological Potentialities of a Species"

Since most taxonomists incline to regard their classifications as signifying phylogenetic relations it would have seemed that characteristics of a species which contribute to, or influence these processes would be information proper to include in the description of the species. Since "The criterion for biospecific distinctness, for example, is whether or not two groups of individuals interbreed freely in the wild, completely irrespective of their morphological characters" (Cain and Harrison ibid.), there would be two good reasons for including in the specific description information on the mechanisms (where the two groups did not interbreed) which prevented the interbreeding: such mechanisms might themselves be of genetic origin and therefore part of the genotype, or they might be the consequence of other characters of genotypic origin; and in any case they are so close to the essence of the specific identity of the group as to be almost certainly of informational value. Mayr et al. (1953) says that the "gene pool" of which the individuals of a species are "the visible expression and temporary containers" requires "protection against outside disturbance." It is therefore relevant to submit evidence of the nature and security of that protection.

Speciation being usually discussed, in part, in terms of various isolating mechanisms classified as: geographic, ecological (ecoclimatic, ecotopic and ecobiotic), physiological and reproductive, we may consider what information regarding such systems might be included in the diagnosis of a species.

Distribution and Habitat

Most systematic papers give notes on the localities where specimens of the species have been taken but such notes characterize neither the general area in which the organism can live nor its normal habitat. Yet, its distribution is both an index of its ecological nature, *and,* in most definitions of what constitutes a species, is one of the principal indexes of its specific rank. It may not then be naive to wonder why a describer of a species is not required to specify both the general cartographic limits within which a species occurs, and its normal habitat.

For example, plaice "lives on the sandy parts of the European continental

[4]This is not to be taken to mean that the authors are advocating the elaborate verbal apparatus proposed by Gregory.

slope down to forty, or in the far north even a hundred fathoms, between the western Mediterranean and the White Sea around Iceland and the Faroes" (Wimpenny, 1953) and the "species is characteristic of sandy bottoms, where, doubtless, it can lie with the margins of the fins under the sand, or even more of the body" (Graham, 1956). Plaice is thus distinguished from the flounder which "unlike the other species of Pleuronectidae, . . . ascends rivers to considerable distances, and during an appreciable period of its life-history it exhibits a preference for brackish or even fresh water" (Jenkins, 1950), and "is found in fresh water from the ages of 1 to 4 years after which it remains in salt water" (Lübbert and Ehrenbaum, 1936). Some of the terminology is already available for this purpose (stenohaline, euryhaline, etc.) but there is need for further development; thus, there is need for a word to cover the general characteristic of salinity tolerance (or intolerance)—"halinity" presumably does not serve this purpose; again, there is need for terms to indicate whether a species spends its entire life in a single biotope (monobiotopic) or several (polybiotopic). On the other hand, although terminology exists to indicate the migrations made by polybiotopic species (see Myers), it is not used in taxonomic diagnoses.

Reproductive Habit

By this is meant the spawning place, time and behavior. Some of the differences between plaice and flounder, in these respects, are indicated by the following authorities:

Plaice: "while spawning takes place throughout its area of distribution where the water is of the right salinity the mature fish congregate in a number of spawning grounds. The diameter of the egg varies with salinity from 1.65 to 2.2 mm." (Wimpenny, 1953: Graham, 1956).

"Contrary to the Salmon, the Flounder's migration to the rivers is for the purpose of obtaining food, its seaward movement for spawning. Good catches are made in the estuaries following a frost. The fish are then heavy with spawn, which, however, is only discharged in deeper water." (Jenkins, 1950). "The Flounder's egg is one of the smallest of pelagic fish eggs (0.8 to 1.15 mm diameter: Graham 1956), the number carried by an adult female of average size is greater than in any other Pleuronectid, and probably account for the fact that in contradistinction to the other members of its family, the Flounder female is less abundant than the male." (Jenkins, 1950).

The terminology for these characteristics is available.

Population Size

Although the principal discussion of this feature is given in a later section, where its significance is treated differently, it is mentioned here because of its very great significance among the determinants of the phylogenetic processes. If it can be correct to say that there is "greater variability of common species (abundant in individuals) than of rare ones" (Huxley, 1940) and, further, that "it is important to realize that the frequency of mutant genes represents an equilibrium between mutation-frequency and selection, that variability represents a further equilibrium between recombination and selection, and that the size and structure of the population will have effects on both these equilibria," (Huxley, 1942), it must be valid also to wish to have some indication of population size in the diagnosis of the species.

Life Span

This is in the main complementary to the preceding characteristics, being an important element of vital statistics, and significant in the phylogenetic process. However, it has physiological implications and may also have relations with reproductive habit. When determined it is recorded of course very simply.

Autecological Aspects: The Species as Organism of Stabilized Biapocrisis

Although Huntsman's term biapocrisis has not gained general acceptance in ecological literature, we are inclined to the view that the *whole* for which he coined the term, ("the response of the organism as a whole to what it faces where it lives," Huntsman 1948), does require a special term. Moreover, the definition just quoted is preceded in his paper by the statement that the term was coined "in order to specify clearly what knowledge is required to predict the distribution and abundance of organisms," and since what the authors have in mind is the assembly of this required knowledge in systematic form, it is believed that a term which helps in the process of systematisation is of value, even if the biapocritic data are considered only part of the array of knowledge required for the purpose stated.

"The responses which are of primary concern are by reproducing or not reproducing, by growing or not growing, by moving or not moving, and by surviving or not surviving," (Huntsman l.c.) and, in effect, Huntsman's exposition of his biapocritic method shows it to consist of a logical and systematic analysis, employing field observations and data from specially designed experiments, of the factors determining reproduction, growth, movement and survival.

It is obvious that the assembly of these biapocritic data is of first importance for the purposes the authors have in mind, namely the prediction of distribution and abundance which, as the above quotation shows, were those of Huntsman before us. For this reason a large part of the diagnostic schedule (see Rosa (1957) Appendix 2, and Kesteven, Rosa and Holt (1958) Annex) being used in the authors' work is devoted to the bionomic and biapocritic features. It is here, perhaps more than elsewhere in this schedule, that the difficulties of reduction of data and the need to find biological constants must be resolved. But here also the authors become involved in two problems of interest to the taxonomist: physiological raciation (or even speciation) and phenotypic plasticity.

Dealing first with the matter of biological constants: In the literature are found accounts of experiments and of analysis of sets of field data from which equations are prepared expressing mathematically the relation between values of some characteristics of species under investigation and of some factors of the environment which appear to exert a significant influence on the characters of the species; these equations contain constants which characterize and give a measure of the response of individuals of the species to the selected factors at various levels of intensity of influence. Clearly the more of such constants that could be available, and the greater their reliability, the more accurate and reliable would be the description of a species. However, there is a paucity of such constants and the work on them is still uncertain because of the difficulty of disentangling the range of response of individuals of, say, a single

generation in one locality, from the genotypic plasticity of the species. That differences other than morphological may establish specific status is certain, even if, for the most part, the morphological features by which the distinguishing functions are subserved should have attracted prior attention and be easier of demonstration. It is not a question of which came first (presumably in general they go together), but that for the purposes required here the non-morphological are too important to leave unreported. As example of what is meant the conclusion of a paper by McCauley (1958) is quoted: "Hart (11) concluded, in his study of geographic variations of fresh-water fish, that there was no strong evidence in his material of the existence of physiological races within species. Any physiological differences he uncovered were accompanied by morphological differences that gave each group the rank of subspecies. The findings of the present investigation are similar to Hart's observations. The two geographic groups of *Salvelinus fontinalis* which are considered to be morphologically similar did not display any difference in their lethal temperatures or in the relation of cruising speed to water temperature. The geographic groups of *S. alpinus,* on the other hand, are considered to be distinct subspecies and this classification is confirmed by the significant difference in their lethal temperature relations."

The taxonomists are likely to be a little reluctant to enter this field. "Are the 'physiological races' of insects, etc., to be given specific rank when they are partially or wholly intersterile but yet show very little morphological distinction? The museum systematist naturally shrinks from this course, as it puts the main onus of assigning specimens to their correct category, on ecological or experimental methods for which there is neither space nor time in the routine work of a museum." (Huxley 1940).

But since fishery biologists are so actively engaged in study of such matters a rich flow of relevant data is being produced each year and it might be well to give early thought to its systematic assimilation into the taxonomic apparatus.

Species as Population

In the (Kesteven et al. 1958) paper referred to at the beginning of this contribution, reference was made to the general significance of population size and, in the face of some scepticism, the authors have ventured to speculate about the possibility of each species having an intrinsic size potential. The genetic significance of population structure and size is of course unquestionable, as indicated by the earlier quotation from Huxley and by the work of Fisher, Sewell Wright and many others, but that is the other side of the coin. What we have in mind is that the sum of the biapocritic characteristics of the individuals of a species population result, among other things, in a population whose size is a constant times the value of certain features of the environment, just as is the physiological response of an individual; and the constant would be regarded as being a genotypically determined characteristic of the species (or the result of a set of such characters). Grounds for this idea are partly argument by analogy (with some reference to ideas on the super-organism), and partly evidence from comparison of differently located populations of a single species, and from comparisons of populations of closely related species in practically the same location. The argument by analogy refers to the determinants of typical size of individuals of a species. Although there is generally considerable variation between individuals of a species, within a single population, the pattern of

growth, including its rate, the shape of the curve of growth against time, and the upper limit of size, lies within certain limits which are fixed less by environmental factors than by the structural and functional characteristics of the body of the individual, and the relations between them. Haldane's speculation about the breast bone of an angel, and speculative explanations for the extinction of certain giant reptiles, indicate the limits imposed upon a species once its *bauplan* becomes determined. It seems to us that similar limits are imposed on the population of a species (using this analogously with "body of an individual") once its structural and functional characteristics become determined within the context of the environment in which it lives. Of course the restrictive relations between the elements of a population are much less intense than are those of the body of an individual and relatively the variations in magnitude of a population are far greater.

Every fishery worker must have been impressed by the differences in sizes of populations of different species, even closely related, within a particular locality; many may have reached the conclusion that such differences cannot be explained by single characteristics such as fecundity or position on the food chain. Similarly each worker must have been impressed by the persistence, through areas of different size, of a ranking (in a kind of numerical hierarchy) of various species or groups. For example, most clupeoids form large populations and hold a dominant position in whatever habitat they are found.

Table 1 will serve to illustrate something of what we have in mind. This table has been developed from one published in Graham (1956) to the columns of which some figures have been added whilst adding two columns relating to catch. The data of the first catch column and the other added figures have been taken from the official publications as indicated in the footnotes; those of the second catch column have been arrived at by simple calculation from the first column and using rough average weights of the fish in this catch. These catch data are assumed, with appropriate reservations, to constitute some index of the relative sizes of the populations of the different species listed in the table; and it is clear that there is little relation between these catch figures, and hence on our assumption, between population size, and fecundity or species average size. Thus, ling has the greatest relative fecundity among the gadids, although its population is the smallest but one. Cod, of which the population is greatest, has fecundity approximately the same as that of saithe and haddock whose populations are only one tenth the size of that of cod. Nor does position on the food chain provide an explanation, as is clear from comparison of the sardine with the gadids.

Population size is usually discussed in terms of fluctuations about an unspecified absolute magnitude, and in such discussions it is assumed that certain environmental factors, density-dependent or density independent or both, relax and contract the limitations they impose on each population and cause declines or permit expansions: it is of little value to say that this means that if these restrictive factors were removed from bearing on a population it would continue to increase without limit. Such speculation can be thrust aside because these populations exist within strict limits imposed by biotic and abiotic factors and because the effect of these limits is not the result only of the intrinsic character of these factors, but also of properties of the species. The factors of the environment of a particular species that permit the play of its potentialities, and place restrictions on them, exercise their influence on the population through and by

TABLE 1

COMPARATIVE TABLE OF FECUNDITIES AND CATCHES

Taxonomic Groups	Catches Weight[4] (in '000 k)	Catches Numbers (in '000)	Fecundity[1] Range	Individual[1] Weights (g)	Individual[1] Lengths (cm)	Fecundity per 10 g fish
Gadidae —						
Ling	44,515	5,560	12-28 million	8-24 k	45-61	12,000
Cod	2,690,342	672,000	1.8-9 million	4 k[2]	60-70[2]	4,500
Saithe	257,586	64,300	2-8 million	4 k[2]	55-70[2]	5,000
Haddock	331,738	94,700	12,000-3 million	80-6,900 k	22-85	4,500
Tusk	23,444	—	0.75-2.25 million	—	—	—
Bothidae —						
Turbot	7,134	1,110	8.1 million	6,4 k	—	12,700
Pleuronectidae —						
Flounder	11,245	21,000	0.56-1.6 million	348-723	27-38	22,000
Plaice	98,743	76,000	16,000-346,000	125-2,580	23-61	1,500
Clupeidae —						
Sardine	224,902	6,420,000	15,000-55,000	17-53	13-19	10,000
Herring	2,812,665	22,300,000	12,000-33,000	103-150	21-29	2,200
Ammodytidae —						
Sand-eel	112,000[3]	8,000,000	13,350-36,300	8-20	14-18	18,000

[1]Graham (1956)
[2]Ann. Biol. Copenhague, (1956), 13, 1958.
[3]Seventh Meeting Permanent Commission, International Fisheries Convention (1946) (mimeo.), 1958.
[4]Bull. Statist. Pêch. Marit. Copenha., (1956), 41, 1958.

virtue of the characteristics of the species itself. Heat is of itself not intrinsically lethal, its levels are favorable or unfavorable for each species because of the characteristics of the tissues, cells and proteins of the species. This is true of all factors that influence the functioning of a species, and it would seem that among a group of biocoenotically similar species, that one whose population is greatest is the one whose characteristics constitute a mosaic making greatest use of each of the factor-ranges offered by the environment.

Consider the matter from another viewpoint. It is known from research work among birds that there are lower levels of population density below which maintenance of the population is impossible; below these levels certain ethological and physiological conditions are not met. This situation then (apart from the circumstances that depressed the population below the critical level) is chiefly a result of the intrinsic characteristics of the population. At the other extreme it is known from work, chiefly on insects but also on populations of small animals of other phyla, that populations within restricted environments establish equilibria whose levels are determined by certain limiting factors so that, no matter how liberal may be the supply of certain materials, or how favorable certain factors might be held by the experimentalist, the population fluctuates about a level determined by the limiting component or factor. The timing of the supervention of limiting factors for any population, or the rate at which the limiting values are approached in the course of the change from one level to another, is determined in some cases by external factors and in others by factors within the population itself. The latter group of factors is not adequately represented by situations of "arithmetic" character such as metabolite accumulation in closed or partially closed systems of simple populations; a better example is that of the inhibition of the growth of slowly growing members of a population by substances released by the larger, more rapidly growing members of the population, demonstrated by Rose (1959) in the case of tadpoles and fish the essence of which is that the arithmetic increase itself generates changes in other components whose influence increases geometrically. Again we arrive at the concept of the fitness of the species to its environment with respect not only to the structure and functions of its individuals, but also to its population magnitude; and, we must assume, to the structure and dynamics of the population.

Furthermore, recollecting the laboratory experiments with populations of small animals, and referring to earlier remarks about the impossibility of postulating completely relaxed environmental factors, we may assert that no natural biotope is limitless.

Apart from the general biological implications of Kinne's suggestion and of the development of that idea here, two immediate applications for this concept are seen. Firstly, if the population characteristics of a species can be considered in this way then there is available a method of systematic approach to description and appraisal of living aquatic resources and effective extension of the established techniques of cataloguing species. Secondly, and similarly, this concept has important relevance to proposals for transplantation of species: such operations need not be intelligent guesses but informed prognoses.

LIST OF REFERENCES

Baerends, G. P. and J. M. Baerends-Van Roon
1950. An introduction to the study of the ethology of cichlid fishes. Behaviour, Suppl. *1:* 1-243.

Breder, C. M.
1926. The locomotion of fishes. Zoologica (New York), *4* (5): 159-297.

Cain, A. J. and G. A. Harrison
1958. An analysis of the taxonomist's judgment of affinity. Proc. Zool. Soc., Lond., *131:* 85-98.

Graham, M.
1956. [Ed.], Sea Fisheries: their investigation in the United Kingdom. E. Arnold (Publishers) Ltd., London, 487 pp.

Houssay, F.
1912. Forme puissance et stabilité des poissons. Coll. Morphologie dynamique, Paris, *4:* 1-372.

Huntsman, A. G.
1948. Methods in ecology—Biapocrisis. Ecology, *29* (1): 30-42.

Huxley, J.
1940. [Ed.], The new systematics. Oxford Univ. Press, 583 pp.

Huxley, J.
1942. Evolution: the modern synthesis. Allen and Unwin Ltd., London, 645 pp.
1958. International Council for the Exploration of the Sea, Bull. Statist. Pêch. Marit. Copenhagen, (1956), *41.*
1958. Ann. Biol. Copenhague, (1956), *13.*

Jenkins, J. Travis
1950. The fishes of the British Isles both fresh water and salt. F. Warne and Co. Ltd., London and New York, 408 pp.

Kesteven, G. L., H. Rosa, Jr. and S. J. Holt
1958. A note on abundance and distribution of marine organisms of economic importance. Inter. Un. Biol. Sci., Ser. B, (24): 287-297.

Kinne, O.
1958. A programmatic study of comparative biology of marine and brackish water animals. Inter. Un. Biol. Sci., Ser. B, (24): 87-92.

Lübbert, H. and E. Ehrenbaum
1936. Handbuch der Seefischerei Nordeuropas. II. Naturgeschichte und wirtschaftliche Bedeutung der Seefische Nordeuropas. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Nägele) G.m.b.H., Stuttgart. 337 pp.

Mayr, E.
1942. Systematics and the origin of species. Columbia University Press.

Mayr, E., E. G. Linsley and R. L. Usinger
1953. Methods and principles of systematic zoology. McGraw-Hill, New York, 328 pp.

McCauley, R. W.
1958. Thermal relations of geographic races of *Salvelinus.* Canad. J. Res. (Zool.), *36:* 655-662

Norman, J. R.
1934. A systematic monograph of the flatfishes (Heterosomata). I. Psettodidae, Bothidae, Pleuronectidae. Brit. Mus. (N.H.), London, 459 pp.
1948. A history of fishes. A. A. Wyn, Inc., New York, 436 pp.

Permanent Commission, International Fisheries Convention 1946
1958. Seventh Meeting, (mimeo.).

Rosa, H., Jr.
1957. Synopsis of data on the species of the genus *Rastrelliger* (Jordan and Starks, 1908). IPFC Meet. Sub-Comm. on Rastrelliger, Malaya, September 1956, (mimeo.).

1957. Synopsis of data on hilsa *Hilsa ilisha* (Hamilton-Buchanan) 1822. IPFC 7th Session, Bandung, Indonesia, May 13-27, 1957, (mimeo.).
1957. Synopsis of data on whales. (mimeo.).
1957. A synopsis of biological data on the species of *Trichiuroidei*. (mimeo.).
1957. The survey of living aquatic resources. Proc. Gulf Caribb. Fish. Inst., Florida, 9th Ann. Session, Bahamas, Nov. 1956. pp. 153-170.
1958. A synopsis of biological data on tench *Tinca tinca* (Linnaeus, 1758). (mimeo.).

Rose, S. Meryl
1959. Failure of survival of slowly growing members of a population. Science, *129* (3355): 1026.

Schuster, W. H.
1958. Synopsis of biological data on milkfish *Chanos chanos* (Forskal, 1775). IPFC 8th Session, Colombo, Ceylon, Dec. 6-22, 1958, (mimeo.).

Wimpenny, R. S.
1953. The plaice. E. Arnold and Co., London, 145 pp.

Woodger, J. H.
1945. On biological transformations. In: *Growth and form. Essays presented to D'Arcy Thompson* ed. W. E. Le Gros Clark and P. B. Medawar. Oxford: Clarendon Press.

FRIDAY—NOVEMBER 13

Chairman—PAUL E. THOMPSON, *Chief, Branch of Fishery Research, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Washington, D. C.*

Fisheries Problems in the West Indies

ERNEST HESS
Fisheries Adviser
West Indies Federation

THE GENERAL DEVELOPMENT of the fisheries in the Caribbean has been discussed by the Institute at previous sessions. At the Ninth Annual Session (1956) Wiles presented a paper on this subject and at the Tenth Annual Session (1957), the progress during the decade 1948-1957 was reviewed in four special papers, covering the fields of fisheries technology, economics, education and biology. More recently, the General Secretariat of the Caribbean Commission prepared a review of "Caribbean Fisheries Development, 1955-1959," as Document No. 1 of the Third Caribbean Fisheries Seminar, which was held under the auspices of the Commission in St. Martin, Netherlands Antilles, from 3-9 July, 1959 (Anon. 1959a).

Resources

MARINE: It is generally recognized that, at present, the waters of the Caribbean are not overfished and that, under the stimulus of various fishery development schemes, larger catches are possible and are to be expected. Close inshore grounds, fished for many decades by thousands of small craft, as well as the spiny lobster and turtle fisheries may be exceptions to this. On the other hand, off-shore banks and cays have barely begun to be exploited and, in the almost complete absence of systematic exploratory fishing in the area, their potentials are unknown. Special attention has recently been paid to the possibilities of exploiting the tuna migrations in the Eastern Caribbean and long-lining experiments are being reported from an increasing number of territories. The shrimp resources of the Guiana continental shelf, adjacent to the Caribbean, are receiving increased attention by commercial interests and may require conservation measures before long. Through the good offices of the Caribbean Conservation Association, it has been possible to procure shipments of green turtle hatchlings from their hatchery at Tortuguero (Costa Rica) and liberate them on protected beaches of some Eastern Caribbean islands in the fall of 1959. It is expected that more islands will take advantage of this service next year.

It is clear that, as long as no means are provided to carry out systematic, scientific exploration, especially of the Eastern Caribbean, progress in "deep sea fishing" will be slow and hazardous, though not impossible. It is also evident that such exploration could only be undertaken on a regional, international basis, since none of the territories could afford such long term research on its own, and few, if any, have any real research vessels or trained personnel. The marine biological research laboratories of the region, which have recently

formed an Association of Island Marine Laboratories, and include institutes in the Bahamas, Barbados, Bermuda, Curaçao, Cuba, Jamaica and Puerto Rico, are primarily interested in general marine biological research and teaching, and only incidentally concern themselves with fisheries biology.

Efforts of the Caribbean Commission to list the fish species of commercial importance to the Caribbean territories are gradually bearing fruit. Such lists have been prepared recently for Puerto Rican waters, the French West Indies, French Guiana, the Netherlands Antilles, Surinam and Florida. The Report of the Third Caribbean Fisheries Seminar (Anon. 1959b) contains (Appendix IV) the local and scientific names of the most important commercial fishes of some of the West Indies Territories, including Antigua, Barbados, Jamaica, St. Kitts and Trinidad, as well as an extensive list of the fishes of Puerto Rico.

The Seminar also prepared a list of experts willing to undertake the work of identifying and classifying fishes.

All efforts should be made to interest one of the organizations active in giving technical assistance to less developed countries, such as the United Nations Technical Assistance Board (Special Fund) which has just granted considerable funds for fisheries research to Peru and Ecuador, the International Cooperation Administration (U.S.A.), UNESCO and others in assisting this essential project of exploring the marine fishery resources of the Caribbean.

Fresh and Brackish Water: Considerable progress has been made in some of the larger islands, e.g. Jamaica and Trinidad, in the field of fish culture research and fish farming. British Guiana and Surinam, adjacent to the Caribbean area, are also in the forefront of development of their inland water fishery resources. Monosex culture of *Tilapia mossambica* in fish ponds, concrete tanks and ordinary farm ponds has proven most successful and release of specimens, accidentally or by stocking, in rivers, reservoirs, swamps and brackish water lagoons has led to the establishment of mixed tilapia populations which, controlled by natural predators, are producing fish of marketable size in many localities.

Through systematic extension work, the Fisheries Division of Jamaica, for example, has stocked with Tilapia over 400 farm ponds, covering almost 1,000 acres, and Tilapia are now sold by local vendors and in local fish markets. In Trinidad, the water reservoirs of some of the oil companies and large estates have been stocked with Tilapia and are yielding good crops.

Fish culture research is continuing, aimed at breeding slow-maturing, fast-growing Tilapia and at determining the best pond fertilization and harvesting practices and the most economical size of fish to produce. Systematic surveys of the fresh waters are contemplated in some of the territories.

Production

Fishery development schemes in operation in all territories have, in the first instance, concerned themselves with increasing the catches of fish from local resources, in view of the great demand for fish in the diet of the rapidly increasing population and the heavy drain on the economic resources of the islands through the importation of large amounts of processed fish to meet this demand.

Boats: The major effort, so far, has been in the field of boat mechanization and introduction of new boat designs. Where local boats, such as the dug-out canoes of Jamaica and the pirogues of Trinidad, were unsuitable for inboard motors, the installation of outboard motors has made greatest progress; thus, in mid-1959, Trinidad and Tobago had some 800 outboard-driven boats (without

Government loan assistance), 62% of its fishing fleet being motorized (including 126 inboard motors), as against 6% in 1946. Jamaica, by mid-1959, had some 450 motorized boats, about 430 using outboard motors procured through a government loan scheme. This is about 16% of the total fishing fleet. Barbados, on the other hand, greatly "assisted" by hurricane Janet which caused considerable losses to the fishing fleet in 1955, turned rapidly from the prevailing, not too seaworthy, planked sailing boats, to a new type of mechanized launch with inboard diesel engine. With extra rehabilitation funds being made available through a government loan scheme, it increased the number of such boats, mostly in the 21 to 24 feet length and 10 to 20 h.p. class, from 32 launches in 1955 to some 415 by mid-1959. This represents 100 per cent of the whole fishing fleet, as compared with 5 per cent in 1953. Antigua, on a smaller scale, has also provided some 50, i.e. 80 per cent, of its larger fishing boats with inboard diesels, under a government loan scheme. The smaller islands have all started similar programs.

It must be realized, of course, that the mechanization of dug-outs and pirogues does not produce more seaworthy boats as such, does not increase their range of action very much, nor does it enable such boats to carry more gear, more fish, nor ice boxes. While such boats will serve a useful purpose under certain conditions, for a long time to come, the necessity of introducing larger, even decked boats, as an integral part of fisheries development, is under active consideration in most of the islands. A recent visit to Jamaica, Antigua, Dominica, Barbados, St. Lucia, Grenada and Trinidad by the FAO Naval Architect to advise on the design of new boats suitable to each unit and its potential fishing methods, and on the improvement of the design and of the propeller selection of present boats, as well as the great interest shown on the subject of design and mechanization at the recent Caribbean Fisheries Seminar indicate the awareness of fisheries administrations in these territories of these needs.

Complementary to the government loan schemes for engines, and for boats in some cases, the fisheries divisions in Jamaica, Barbados and Antigua have established shops for repairing, servicing and training, with excellent results.

Fishing Gear and Methods: It has been stated many times before that the fishing boat is merely a "platform" from which the fishing gear is operated, and that the type of fishing gear to be used determines the type of boat required. Thus, apart from replacing sail and oar by engine propulsion, the introduction of new and more intensive fishing methods than the traditional pot fishing and hand-lining ("banking") in itself calls for improved boats. In addition to the task of increasing the food supply of the population from local resources, the chief aim of fishery development schemes is to increase the productive capacity of the individual fishermen and to better their living standards. Thus, the use of more effective methods of catching fish must be considered as one of the foremost means of achieving this goal. Rough estimates of the average annual production per fisherman, made by an FAO technical assistance expert, range from 0.3 tons in the least productive territory to 2.3 tons in the best (average 0.87 tons) (Salmon 1958). It must be pointed out that such figures include both full time and part time fishermen, the latter being in the majority in some of the territories. They nevertheless reflect the low productivity of the fishermen in some of the territories due to the inefficient fishing methods in common use and to the primitive boat types still in operation, which are limited in their annual

number of fishing days by weather, and which are unable to follow fish seasonally into deeper, off-shore waters.

The fishery officers in all territories either have been or are being provided with suitable boats to try out and demonstrate the use of new types of gear and gear materials and to train fishermen in their use. As mentioned previously, "miniature" tuna long-lines are being tried out at various depths, e.g. in Puerto Rico, Antigua, Barbados, Grenada, etc. Gill net fishing for flying fish, so successfully introduced and universally adopted in Barbados, is being demonstrated in other islands, including Grenada and Dominica. Although in some territories, especially in the Leeward and Windward groups, small-meshed nets and seines are still laboriously hand-knit from sewing cotton thread, the use of machine-knit webbing is becoming more common and, with the introduction of synthetic fibre netting and lines through government experimental fishing demonstrations, modern nets are being adopted at an increasing rate. In many territories, the Fishery Divisions themselves are providing a sales service to fishermen to help in introducing new gear materials until commercial interests or fishermen's cooperative sales organizations are willing to undertake this. In spite of some initial drawbacks with gill nets, such as the difficulty of removing some types of fish from the meshes and the extensive damage done to this expensive gear by sharks in some localities, the advantages of the synthetic fibre materials are fully recognized. This is not surprising, since the life of natural fibres in these tropical waters is rather short, especially, as is often the case, when no net and twine preservatives are used.

New types of gear are being demonstrated, such as high-speed reels for red snapper fishing, multiple trolling gear, floating and bottom long lines. Although some of the fishing operations, including pot fishing, are carried out at considerable depths, the use of power gurdies, or even hand winches, is almost unknown as yet. It should be remembered that the boat mechanization program should not stop at mechanizing the boat propulsion, but should be extended to the mechanization of the fishing operation itself, thus increasing manyfold the number of gear units that can be hauled in a given time and, at the same time, making the strenuous work of hauling pots and long lines from great depths, or hauling gillnets and seines hundreds of fathoms in length, less back-breaking.

It would be of great interest also to test, through well planned experimental fishing, the possibilities of using submerged electric lights to attract fish when seine fishing on dark nights, a method widely and successfully practiced in many parts of the world.

On the whole, it should be the aim of any fishing community to avoid dependence on one or two fishing methods only, thus limiting the scope both seasonally, geographically and species-wise of the fish resources they are able to exploit. It has been said, not without reason, that the most prosperous fishing villages in the West Indies, or elsewhere, are those with the widest range of gear, so that all the fishes within reach, at one season or another, can be harvested.

So far, only some of the experimental fishing boats of the fishery officers have been provided with modern fish finding instruments. The successful introduction, however, of more intensive fishing methods will depend to a large extent on the ability to locate fish schools in mid-water and near the bottom of the fishing grounds.

In a recent issue (Sept./Oct. 1959) of the "West Indies Fisheries Bulletin," the author has discussed in detail the problems of handling and distributing fresh fish in the West Indies (Hess 1959).

As mentioned earlier, fisheries development schemes have, in the past, put the main emphasis on increasing the production of fish, without always giving due consideration to the fact that increased landings create problems of their own in the holding, transporting and marketing of these very perishable products. What may have been adequate when most fish were sold directly out of the boat to the consumer, at the beach, is no longer sufficient when increased catches must be carried longer distances from fishing grounds to landing places and must reach many new inland consuming centers and urban markets. Thus, as production increases there is need for improving the facilities and methods of handling the fish in the boats, at points of landing and during transport, distribution and storage on land. There is little sense in catching more fish, unless they reach the consumer in good merchantable condition. The amount of fish available to the consumer can and should be increased, above all, by eliminating all waste caused by fish spoilage. The main principles of preventing spoilage must be dinned again and again into all personnel handling fish, from the fisherman to the retailer: speed of handling, coolness and cleanliness. Any prejudice that may still exist in some quarters against iced fish must be overcome and the need for immediate and rapid cooling of the fish to as near 31 degrees F. as possible, and their maintenance at this temperature throughout the distribution chain, must be thoroughly understood by all.

When better handling and distribution methods and facilities assure that the consumer demand for fresh fish by both urban and inland rural markets, many of which have hardly been touched, are really and regularly satisfied, the problems of short seasonal and often quite local glut landings will have been minimized. It is strongly felt that the main efforts in most of these territories should be made in this direction, i.e. the development of the market outlets for fish as fresh (chilled) fish. It is believed that this can be achieved with less capital outlay (for costly freezing and processing plants) and bring better returns to the fishermen. The main requirements are: liberal ice supplies; suitable, rapid transport facilities by land and by sea; sufficient cool storage space at marketing centers; and an educational campaign among all who handle fresh fish.

With few exceptions, once the fresh fish markets have been fully developed, no real surpluses exist in these territories, to support any fish processing or fishmeal plants. It is true that with the introduction of new types of gear, e.g. otter trawls, new species of fish may be landed which at first may not be readily merchantable and for which new markets will have to be found.

Export possibilities appear to be limited to a few special products, such as spiny lobsters (frozen tails or frozen whole), shrimps (frozen), green turtles, and tuna (plans for a tuna cannery in Trinidad are in an advanced stage), with the U.S.A. as the main market.

While in most territories retail market buildings for fish are gradually being provided by Governments at the larger landing centers and in consuming centers, usually equipped with concrete slabs and running water, and occasionally with cold rooms for over-night storage of local surpluses, unfortunately few territories have any fish marketing organization. The result is that the fishermen are usually at the mercy of local hucksters and maybe a few outside buyers,

except in large centers where wholesale marketing by auction may take place.

If an adequate daily fish marketing intelligence service were available in each island, informing a central office of the landings at the main fishing centers each day, the center could direct the orderly distribution of the landings towards all markets, to assure that all are adequately supplied at minimum effort and transportation cost, and by the most direct routes to insure rapid delivery and preservation of quality. Whether such a marketing intelligence center should be operated by Government, by a fishermen's co-operative union, or a territory-wide fisheries association, is outside the subject of this paper.

Fisheries Statistics

In most of the territories, a system of registration of all fishing craft and gear, usually recording size and value, use of inboard or outboard motors, is established. It is usually only possible to collect accurate and complete information where registration is compulsory by ordinance. Trade statistics to indicate the country's imports and exports of fishery products are generally collected by customs and commerce departments of governments, and such statistics are the most complete and detailed ones available, as a rule. On the other hand, due to the large number of landing points and markets, the collection of catch and market statistics has proven very difficult, and no accurate figures are available for any of the territories. Estimates are in some cases based on the collection of daily market statistics in the major markets, as is done in Trinidad, with indications as to the origin of each lot entering the market; whereas in other territories, landing statistics are collected directly at the major beaches. Since in most cases only about 50 per cent of the total landings are reached by these systems, a properly organized and easily applicable standard system of sampling for collection of catch statistics should be provided.

In any case, the current common practice of collection of statistics only during "office" or duty hours of the market clerks, which bear no relation, as a rule, to the hours when the fish are actually landed, should be changed. Fishing operations cannot be carried out according to government office hours; neither should the collection of fisheries catch and market statistics.

The Caribbean Commission is endeavoring to establish a list of commercial fish species for which catch statistics should be kept throughout the area.

REFERENCES

WILES, DUDLEY W.
1956. Developing a Caribbean Fishery. 9th Ann. Proc. G.C.F.I., pp. 150-153.

ANON.
1959a. Caribbean Fisheries Development, 1955-1959. Caribbean Commission, Document 1, Third Caribbean Fisheries Seminar. 43 pp., processed.

ANON.
1959b. Report of the Third Caribbean Fisheries Seminar. Caribbean Commission. 43 pp., processed.

HESS, E.
1959. Fresh Fish Handling and Distribution Problems. West Indies Fisheries Bulletin No. 5, Sept./Oct., p. 1-16, processed.

SALMON, G.
1958. Report on the Fisheries Industry in the Countries served by the Caribbean Commission. FAO Technical Assistance Report No. 781. 88 pp., processed.

The Role of Government and Industry in Fisheries Development with Special Reference to Under-Developed Countries

Cecil Miles

Regional Fisheries Officer for Latin America (Northern Zone), Food and Agriculture Organization (FAO) of the United Nations, Mexico City, Mexico.

Summary

The extent to which government regulation and management of the fisheries is justified will depend on the over-all policies of the administration. Although decisions will in the long run be determined by over-all socio-political and economic considerations, it is important that advice on the technical aspects be obtained through trained fisheries personnel.

Because of their common-property nature, the economics of the fisheries will involve special factors which are not apparent in terrestrial activities, where economic "rent" is involved. These may require the attention of specialized fishery economists. Also, both fishing and fish marketing have in the past involved unusual risks but these and the concomitant compensatory cost of financing must disappear as a result of technical development, as will also the concept that fishing is traditionally a lowly occupation. The concept of "incentive" is discussed.

Different types of restrictions are evaluated, and it is stressed that they should not be imposed for emotional reasons but only if there is strong indication that they will lead to sustained optimum consumption; they must be continuously re-appraised through measurement of results.

Self-imposed quality standards and auto-regulation by competitive industry, while healthy signs of a growing awareness of the problems, cannot entirely replace the legitimate role of enlightened government, which alone has access to all the data on which to base its ultimate liability to all sectors of the economy and has the means (and the responsibility) to employ impartial specialists trained in aspects which are not of immediate concern to industry.

Space does not permit of exhaustive treatment but examples are given to illustrate the extremely complex nature of fisheries philosophy as an indication of the need for reconsideration of administrative and institutional action, especially in the so called "under-developed" countries.

Introduction

It is my purpose in this discussion to show what I believe to be the legitimate role of governments and how the administration and industry should work together towards the common aim. The common aim is, of course, to get high quality fish, on a sustained basis, to all those people who want to eat fish, or who would eat fish if it were available and the price were right or if it could become a more familiar commodity in their shopping baskets. In the long run this is the only consideration involved, and the function of the different firms and governments are, or should be, consciously directed towards this economic objective, everything else being incidental. Of course, it is not always immediately obvious that each of us is merely performing an economic function, and some-

times it is difficult to see beyond the immediate incentive which impels us to exert our efforts in one direction or another, but the two things are intimately connected.

It is my belief that this word "incentive" should receive a great deal of attention, and it might even be proclaimed as a golden rule. There is hardly any human activity which is not performed for incentive. This incentive may be, as far as the consumer is concerned, price, quality, or just the satisfaction of a desire; for the fisherman, a means of livelihood; for the investor, profit; for those in employment, wages; for the scientist, a career; for government, basically the need to satisfy the electorate as a whole and keep in office; for the government employee the safeguarding of his all too often precarious employment which, in the case of properly trained fisheries personnel, should simply mean the conscientious pursuit of the aim already mentioned of getting fish to people, but which in a few cases, especially in countries where the need for proper professional training is not fully appreciated, may unfortunately be interpreted as a mandate to impose restrictions for their own sake.

It is only when a proper balance is struck between these different, and often conflicting motives, that optimum results will be obtained. In the long run some sort of equilibrium will establish itself, and the different incentives will cancel themselves out. If the return to the operator is too low, the least efficient or the least active will seek other kinds of employment and income will rise. If a fishery becomes overcrowded, that is to say if the total product cannot be marketed or if depletion occurs, or if, as is more often the case, the existing cake is being cut up into too many slices, the marginal outfit will be forced out of business. If the consumer's requirements, as regards price and quality, remain totally unsatisfied, there will obviously be no business; if the industry can satisfy the consumer and still make a legitimate profit, it will prosper.

Should There Be Government Control?

It is always difficult to determine where government intervention directed towards these aims should commence and where it should cease. Fortunately, this is not a technical problem, but one which has to be decided by the community through the political machinery which, although necessarily cumbersome, does to a smaller or larger degree provide the means whereby policies can be changed when they are notoriously inadequate or contrary to interests of the majority, it being the job of the technician to place the policy maker in possession of the facts, to interpret them to the best of his honest belief and to let him take over from there. It is a healthy symptom that the present historic trend is to equate "government" with "honest government" and "industry" with "enlightened industry."

While the author believes that it is not possible to endorse a policy of *laissez-passer* at the present stage when a limited management of the economy is beginning to show results, there may nevertheless be some logic in the argument that there is little more justification for government to determine who should and who should not fish, and where and when, or on the other hand for protecting the entrepreneur against his own actions (for instance when too many operators invade a profitable fishery) than is the case in any other business. Rightly or wrongly, however, increased government intervention seems to be a sign of the times in which we live and all countries are moving,

at a faster or slower rate, towards collective management and regulation of the economy. Economists state that, as a result. major world depressions and periods of vast unemployment are now a physical impossibility. Hence, what yesterday appeared to be an unwarranted imposition—take income tax for example—is today accepted as a legitimate and necessary contribution to the commonwealth.

The effectiveness of broad policies must always depend on the quality and training of the people who are employed to implement them, and it is part of our duty in the international organizations to help those governments which feel the need for it, particularly those of the so-called "under-developed" countries, towards a better understanding of the principles involved and of the kind of training which is required at the technical and administrative levels if desirable results are to be obtained.

A number of intelligent people still claim that the economic laws should be left to work themselves out and that government should restrict itself to police and military protection of human rights. The doubt has also been expressed as to whether peasant communities (subsistence fishermen) who do not set themselves a high target, should be dispatched on what Kesteven (1952)[1] so picturesquely describes as "a needless saga of human trial" involving more work, in order to get more money, in order to have equipment, which will eventually give them more leisure.

While the expression of these opinions must be respected, it does seem that the world has become a better place for most of us since a concern has begun to develop for the common welfare, although on the other hand exaggerated protection may tend to keep the least efficient operators in business.

Nevertheless, there are certain considerations which distinguish fishing from most other human activities and which may have to be taken into account. In the first place, one of the most obvious aspects of any business activity which takes place on land and which must, in fact, be considered before a farm or a factory can commence to operate is rent. Only in the case of extremely marginal land is this factor absent and as the land ceases to be marginal, the occupier, willy-nilly, acquires a rent, which is the value of the improved land in excess of new marginal tracts.

With the exception of some inland waters, the now extinct feudal fishing rights in Japan and such collectively owned resources as certain oyster beds in Britain, the fisheries have traditionally constituted a common-property resource, although a government may reserve fishing rights and waters within its national boundaries to fishermen of that country, and although the licensing of fishermen and fishing boats and in some cases the granting of concessions may constitute a pseudo-rent, this does not usually alter the common-property nature of the resource, since the surplus yield of the water mass itself is not capitalized but dissipated (Scott, 1956) although these considerations do not hold good for boats, gear and shore installations.

Hence, there is as a rule little or no incentive for industry to concern itself over the conservation of the resource, since if a particular operator does not exploit it to the maximum, others will. As a result, a fishery, which should be a rich and self-renewing resource, after an initial period of large profits often adjusts itself in such a manner as to provide only a poor livelihood for those

[1]Kesteven does not, however, in his paper, specifically endorse a laissez-faire policy.

engaged in its exploitation. This in turn tends to attract and retain, at least in the subsistence fisheries, only those laborers possessing the lowest level of skills and aptitudes, so creating a vicious circle, although a definite tendency towards improvement is becoming apparent as the fishing centers gain contact with and share the benefits of the community as a whole.

When conditions get too bad organized industry will associate itself to consider remedial measures, and this is all to the good if it can be done successfully. But often industry is unwilling to divulge its business to competitors or to hire analysts, and the result is an appeal to the administration (by those who were previously opposed to government intervention), coupled with requests for financial assistance and nearly always with the idea that those who are already in should be protected from newcomers. Particularly in countries where the consumer is quality conscious, it is usually good business for industry to put its own house in order in this respect (Wilder, 1958). But where there has been no consumer education and industry is out for what the traffic will stand, it is difficult to see how government control is to be avoided.

The subsistence fishermen do not as a rule possess the initiative necessary for collective action, and, if they are aware that the possibility of improvement exists, they do not know to whom to address themselves for help. Still less are they likely to pay much attention to quality.

It is apparent that the responsibilty must rest on government. If the framing of policies is entrusted to competent persons, it is probable that emergency situations can be avoided, i.e., that situations will be handled when they are still trivial.

The Fishery Personnel

It is fortunate that, in many countries, a proper government awareness of the complexity of the fishery problems is becoming apparent, and people are being trained. There are still, however, many instances where it is considered sufficient to set up a fisheries desk in charge of an untrained junior civil servant and in such cases the government is indeed fortunate when the resultant action is of a constructive nature.

One obstacle to wise fishery management has been the difficulty in bringing together the different skills required, even where they exist. In the ultimate analysis the logistics of fish marketing cannot be isolated from the general socio-economic picture and, therefore, the trained economist must play a principal advisory role in determining how much fish is needed, how "need" can be translated into "demand," how costs and supply of fish and labor must be correlated with marketing and to what extent the flow of fish and fish products should be encouraged through price control, subsidies, credits, etc.

On the other hand, the fishery biologists have in the course of their work encountered situations regarding the magnitude and availability of the resource which lend themselves to mathematical analysis of the kind used by the economist and without which the decisions of the economist may falter. Nutritionists also should have their say in respect of the kind of foodstuffs which people should be encouraged to consume.

Unfortunately, these different specialists are often located in different ministries and have little or no means of communication. A new and highly specialized type of skill is therefore in demand, that of the fishery economist,

who must, in addition to his formal training in economics, acquire considerable familiarity with the daily work of the biologist, the technologist and the nutrition worker, with whom he should form a team. The highly complex nature of the work of such a team, and the impossibility of obtaining results from one untrained civil servant placed in charge of a desk, become apparent if we glance at some of the diagrams and mathematical models which have been developed in attempts to relate the changing magnitudes of fish populations, recruitment, and natural and fishing mortality, to catch, supply, demand, price, etc., taking into account that none of these factors is static and that each may have an extremely wide range.

The Nature of Restrictions on Fishing

It is essential to keep clearly in mind that restrictions on the fisheries may be imposed for one or more reasons, not all of which have to do with conservation of the resource; some of these may, in given circumstances, be legitimate and needed; others may merely fail to achieve the desired (or in fact any) objective; while others again may be positively uneconomical or even harmful. It is only by careful measurement and evaluation, before, during and after the fact, that proper conclusions can be reached as to whether restrictions would be beneficial and, if so, whether the cost and difficulty of enforcement are justified.

Reasons for restricting a fishery may, therefore, be roughly classified into three categories, as follows:

1 BIOLOGICAL

- 1.1 Legitimate conservational (Gerhardsen, 1957)[2] measures, directed towards optimum sustained yield and arising out of an orderly process of measurement and evaluation.
- 1.2 Exceptionally, a policy decision to avert the total extinction of a species, which is partly emotional.

2 SOCIAL AND ECONOMIC

- 2.1 Closed seasons imposed not strictly for conservation of the resource, but so as to obtain a greater yield per unit of effort during a shorter fishing season.
- 2.2 Restriction of fleet (or other fishing pressures) or the imposition of costly licenses (a quasi-rent) to avoid disastrous competition or wasteful investment.
- 2.3 Regulation of flow of labor, seasonal or otherwise. This may be positive, to compensate seasonal unemployment in agriculture or industry, or negative, to discourage competition with professional fishermen or the distraction of terrestrial labor when casual fishing is adventitiously more profitable.
- 2.4 Control of marketing, i.e., to avoid gluts or to market the fish when it is more profitable or of better quality.
- 2.5 Protection of life and property during bad weather, perhaps with due consideration to later availability, or maintenance of craft during slack periods in shipyards, etc.

[2]The word "management" may be preferred, as it conveys better the concept which most fishery scientists have in mind, as Gerhardsen observes.

3 EMOTIONAL AND POLITICAL

3.1 Religious beliefs (total, partial or periodical abstention from certain kinds of food).

3.2 The emotional and usually un-informed demand for "conservation," apparently for the well-being of the creatures themselves rather than for the benefit of man.

3.3 A deliberate decision taken at the policy making level, to impress the electorate or to satisfy political pressures.

3.4 A similar but un-informed decision taken on the "advice" of untrained administrators.

Based on one or more of the above considerations, restrictions may be brought to bear on the fishery through a number of devices, which we may now examine. Each may be applicable to a different set of circumstances, but each will also, under certain other conditions, have disadvantages, or even dangers, which may not be apparent at first sight.

1 Total Prohibition of Fishing for a Given Species over a Period of Years.

Such drastic action may be justified when recovery is sought for an extremely vulnerable resource which has been seriously and demonstrably depleted through uncontrolled over-fishing. It is particularly applicable to sessile organisms such as molluscs of which the habitat is limited to a small geographic area. It may also be indicated for long-lived species which mature slowly, particularly those which are not prolific, and sometimes when the true conservation of a rare form of life is sought for emotional or cultural reasons.

2 Periodic Closed Seasons.

Although the value of closed seasons is often over-estimated, careful evaluation may show them to be necessary. They should never be imposed inadvisedly but only when the indicated result is preferable to the *status quo*. Decisions in this respect, which require vision and mature understanding, are those which are most often taken by the administrator without a full comprehension of all the circumstances involved. There is seldom biological (although there may be economic) justification in the case of short-lived prolific animals, particularly those giving an annual crop subject to heavy natural predation. It must always be proved that the resulting increased production (if any) fully offsets anticipated natural mortality during the closed period, as well as the economic cost of fixed overheads of marine and shore facilities, which will continue irrespective of whether or not there is fishing.

The extent of the overlap between natural and fishing mortality must also be taken into account, as is shown in Diagram I[3], in which, under (a), natural mortality is taken to be only 5 out of 25 units and fishing mortality 20, with a common mortality of 4 units and a residual natural mortality of 1 unit. If fishing is sacrificed, natural mortality in a given period will increase from 1 to a full 5 units and 20 units will, when the season opens, have remained in the stock for reproduction and fishing, instead of 4.

[3]Dr. Richard van Cleve has drawn my attention to the fact that this is an arithmetical over-simplification since the factors are, in fact, exponentially related. This does not, however, substantially affect the general principle which it is desired to demonstrate.

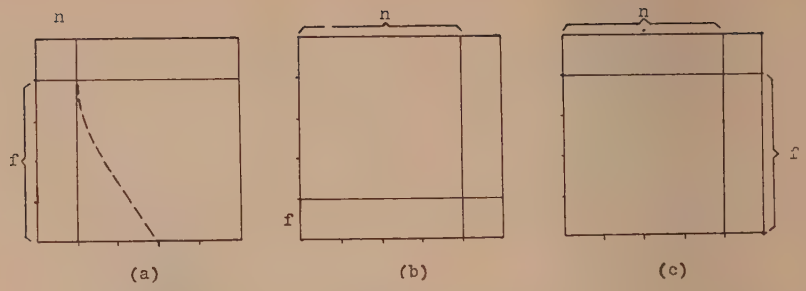


DIAGRAM I

Overlap between natural and fishing mortality, when (a) natural mortality relatively small, fishing mortality relatively large; (b) natural mortality relatively large, fishing mortality relatively small; and (c) natural and fishing mortality both large.

In (b), where natural mortality is large—20 units—and fishing mortality relatively small—5 units—, if fishing ceases, natural mortality will increase from 16 to 20, and 5 units only will be conserved instead of 4, a small gain compared with the sacrifice of 5 fishing units; when both natural and fishing mortality are high, as in (c), if fishing is stopped 20 units are lost to the economy, of which 16 will revert to natural mortality, but 5 units will be protected for reproduction and future fishing, instead of 1 if the closed season had not been established.

It must, of course, be fully understood that Diagram I, which is repeated with variations in the textbooks, is nothing more than an exposition of a general principle and that the real conditions, which are more complex, must also take into account the influence of the socio-political, economic and other non-biological factors, the effect of natural cycles and the fact that since neither fishing nor natural mortality is static, the elimination of the former and the correspondingly increased survival may bring into play new factors, favorable to increased natural mortality, expressed by the hatched line in I (a). This may be expressed percentage-wise as shown in Table 1.

A further illustration of the economics of closed seasons is given in Diagram II, where the total catch in a fishery has reached its peak and has started to descend. If it is assumed that a closed season is imposed at instant x, this will involve a loss equivalent to area "a." When fishing is resumed, there may or may not be an improvement of catch, but let us assume that at point x there has been a recuperation and that thereafter conditions tend to approach the normal curve (the improvement will seldom be permanent), so showing an increase equivalent to area "b," which is less than "a." In this case, the restriction has not shown a profit, although it might at a lower point on the curve, where "b" is in excess of "a." Often, however, the fishing curve may become stabilized (naturally, or as a result of other types of restrictions on fishing pressure), at a level which still does not justify closing the fishery.

It is often open to serious question whether the reason most frequently put forward for closing a fishery, the protection of a stock during its spawning period, has any validity. A point which is often lost sight of is that, in order

to maintain equilibrium, each pair of fish will, on an average, produce only 2 reproducing offspring, *in its whole life,* and that providing escapement is sufficient to take care of this minimum requirement, the loss to future generations of large numbers of potential juveniles is unavoidable, and may or may not be important.

Irrespective of their sometimes doubtful intrinsic value, the establishment of closed seasons usually followed by their progressive shortening, may mean that the fishery simply adjusts itself by employing more men, boats and gear, with a correspondingly higher capital investment. In very many cases, it must be admitted, closed seasons have failed to achieve the declared objective of improving the sustained yield (Scott, 1956).

TABLE 1

Factor	(a)		(b)		(c)	
	With fishing %	Without fishing %	With fishing %	Without fishing %	With fishing %	Without fishing %
Fishing mortality	80		20		80	
Natural mortality with fishing	4		64		16	
Natural mortality without fishing		20		80		80
Survival with fishing	16		16		4	
Survival without fishing		80		20		20
Total stock	100	100	100	100	100	100
% increase natural mortality if fishing stopped.	400		25		400	

3 Quota Systems.

It is often preferable to seek means to relieve fishing pressure other than closed seasons. Where international agreement has been reached by means of a Convention, over-all quotas may be assigned to countries; in other cases (e.g. the Whaling Convention) it may be agreed that fishing will stop when the total catch has reached a predetermined figure. Within countries, quotas may be assigned either voluntarily (or, more frequently, through government action), to companies, to boats or (more especially in the game fisheries) to individuals. In all cases, except perhaps the last, the quota concept involves in effect a closed season, of which the commencement date will, however, depend on how soon the quota is fulfilled after the fishery is opened.

As in the case of other restrictive measures, quota management of fisheries should only be resorted to when we have some idea as to how much fish can safely be removed from a stock without diminishing its sustained optimum contribution to the economy (Hart, 1958).

Perhaps the most outstanding effects of management of a fishery through an over-all quota are: the accentuation of competition (exaggerated fishing effort)—particularly on the nearby grounds, perhaps to the extent that distant grounds are actually under-exploited (Ricker, 1954); abnormally long working

days; the taking of risks which would normally be avoided; and hardship to individuals who are unlucky enough to suffer from breakdowns or illness during the critical period. Some of these disadvantages disappear if quotas are imposed on individual boats or on sub-areas, but this will discourage initiative, since the more enterprising fisherman can take no more than the others (Ricker, 1954).

Inefficiencies arising from the congestion of shore facilities followed by long periods of inactivity during which overhead expenses continue, must also be taken into account, as must the concomitant sociological dislocations. Intensive fishing at the commencement of the season may involve a minimization of growth in the current year.

The establishment of the quota tonnage must necessarily involve careful study and will usually require year-to-year revision in the light of constant evaluation on the basis of a highly developed (and costly) statistical system which will become extremely critical as the quota limit is approached each year. Quotas may additionally have to be adjusted so as to take into account substantial differences in later recruitment arising from "good" and "bad" years.

4 Size Limits.

Minimum size limits are often imposed on the grounds that insufficient

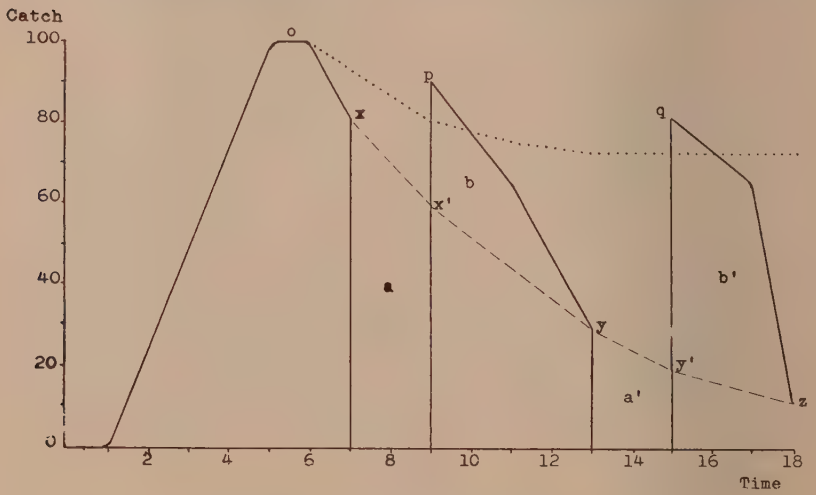


DIAGRAM II

Hypothetical effect of closed seasons.

xx'yy'z represents a normal fishing curve: if it is decided to impose a closed season at instant x and to resume fishing at x' and if as a result the total catch increases so as to give p, reverting to normal at y, the total gain in tonnage will have been equal to area b, but the sacrifice a is greater, indicating that the measure was unprofitable. If depletion continues and fishing is prohibited between yy' with a resulting recuperation to q, the gain b', being in excess of the loss a', may justify the action taken, which would not be the case if depletion were slower, or leveled off at the dotted line.

animals would otherwise fail to mature and reproduce. While it is obviously harmful to a fishery dangerously to reduce the number of residual spawners, the same doubt exists as under 3, above, as to whether the taking of immature fish is essentially a bad thing, provided that there is sufficient escapement, since maximum recruitment may still be achieved by a relatively small number of prolific individuals. There is in most cases so little evidence of any substantial correlation between the abundance of mature fish and commercial production that the effect of size limits on yield is doubtful, even in such an apparently vulnerable stock as the lobster (Turvey, 1957). It does, however, constitute one means of relieving fishing pressure, and it may well be that the growth rate of the sub-legal fish just prior to their natural entry into the catchable classes is such as to over-compensate for natural losses.

Except where a stock is not exploited in the adult stage, it is usually not advisable to permit the wholesale catching of schools of early stage juveniles for reduction purposes by the use of extremely fine mesh nets. Here, the difficulty arises that small mesh nets which must necessarily be permitted for catching species of small adult size may, purposely or accidentally, capture juveniles of other species, and the control of mesh sizes is particularly difficult in the case of mixed fisheries.

When mesh size has to be considered, it is important to attempt to establish for each species the co-efficient of 50% escapement at a given size. While it is true that there must be a good deal of empiricism pending the required original research, especially in tropical waters where so much is lacking, it is disconcerting to find that in many countries there is a general unawareness that such devices exist, and that therefore little if anything is being done to train personnel in their understanding and application, so that such restrictions continue to be legislated without rhyme or reason.

5 Prohibition of Certain Types of Gear.

There can be no discussion in respect of the need for the absolute prohibition of certain extremely harmful fishing methods, such as the use of poisons and explosives, or which involve the use of gear which completely and permanently obstructs a reproductory migration, e.g. in a river.

All too often, however, one finds that certain types of gear which would in fact contribute to optimum exploitation are prohibited in the legislation for no apparent reason. It is common for groups of fishermen using a type of gear to bring pressure to bear for the elimination of other types which they allege, often with little reason, to be contrary to the common good, whereas in fact they are seeking a front to protect their particular interests. Decisions in this respect can obviously only be taken by experts possessing long familiarity with all phases of the fishery.

6 Limitation of Fleet.

Even when there is not yet a depletion of the stock, it is often the case that an increase in the number of boats exploiting a fishery will not have resulted in any increase in total tonnage caught. This situation is sometimes described as cutting the same cake into smaller pieces, and its most obvious effect is unnecessary capital investment by the community and unnecessarily smaller returns per unit of effort expended. As to whether checks should be

imposed is at this stage a matter of policy decision, and the biological factor will only become paramount at a later point when depletion of the stock and a shrinkage of the total catch begin to show up.

Whether adopted for economic or biological reasons, however, limitation of the number of boats (or gear) exploiting a fishery is often the most direct and most easily measurable means of limiting fishing effort, provided that there is also control of size and efficiency, and that the permitted number is established through scientific observation rather than guess-work. It is often difficult to convince a thriving industry of the need for such a restriction until the break-even point is passed and the fishery has become unprofitable. When this happens, industry is often equally insistent on fleet control slanted towards the exclusion of newcomers. Such measures are looked upon, in some countries, as tending towards the establishment of monopolies and when applications are in excess of the established total, serious difficulties may be encountered in allotting boat permits. The imposition of license fees, in order to limit the fleet to the most efficient units, may have the effect of bringing about economic saturation before over-fishing occurs, but it must be ensured that the resulting maintenance of a relatively high yield per unit of effort (and higher profits) does in fact compensate for the fees paid so that these are not passed on to the consumer in the form of greatly increased prices.

7 Economic Controls.

Price control, subsidies, taxes on fish, production quotas for processed fish, limitations on size and number of factories, license fees and other controls of a non-biological nature, may also have a more or less direct influence on fishing operations.

Application of the Above Criteria

It is beyond the scope of this paper to probe deeply into the mathematical aspects of the interrelation between fish populations, year class frequencies, recruitment, mortality, etc. on the lines which are still being actively developed by Beverton, Holt, Kesteven, Schaeffer, Burkenroad, Le Cren, Ricker, Gulland and others. It is, however, aimed to draw attention to these techniques in the hope that administrators may gradually become aware at least of the existence of the general principles involved[4] (only a few will have the time or the specialized training necessary to participate in the detailed reasoning, which is still partly controversial) and to the important fact that biological considerations alone will not suffice to give us the answer to the problems entrusted by the community to government and industry.

As Marr (1954) tells us, "es fácil de imaginar cuán complejas se tornan las variaciones que pueden observarse en las curvas de pesca, cuando la disponibilidad y las tasas de mortalidad natural de pesca varían simultáneamente."

But also, "while the cost of fishing depends partly on the size of the fish population, (conversely) the latter is obviously affected by the size of the

[4] Le Cren (1958) calls attention to the need "for these elaborate theoretical models to be simplified to their essentials" although "their development will (have yielded) valuable improvements to the understanding of the whole subject."

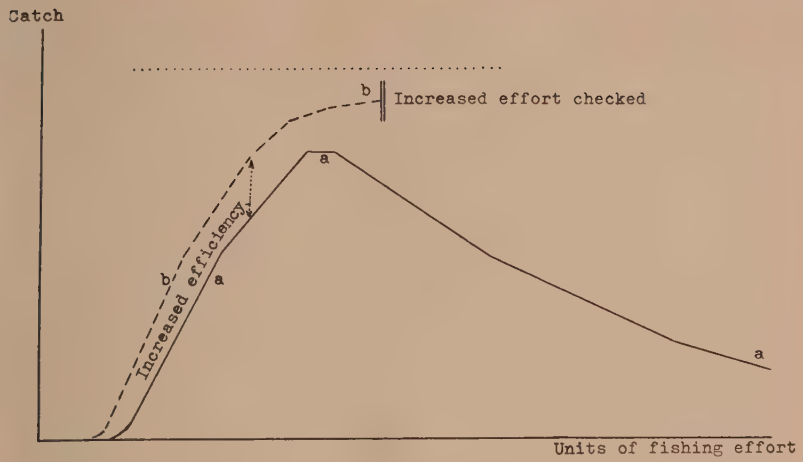


DIAGRAM III

a. "Biological" fishing curve under uncontrolled conditions, assuming successive increases in fishing effort, irrespective of economic factors.
b. Hypotheticai "economic" fishing curve under ideal controlled conditions and improved efficiency.

catch. There is thus a close interaction between economic and biological factors and any full analysis of the size (and behavior) of a particular fishery must pay regard to both. The problem is not merely one of intellectual interest, since it must form the background to any examination of conservation measures." (Turvey, 1957)

As an example, let us examine the standard fishing curve shown in Diagram III, in which a steadily increasing fishing effort (irrespective of time) is correlated with catch. The biologists tell us that, as a virgin fish population becomes exploited, each new unit of effort will, after an initial period during which effort as yet results in little or no return, give a relatively large increase in catch, and that returns will progressively decline to a point of equilibrium, after which increased catch from additional units of effort will be negative.

The final shape of the extreme right-hand part of the curve is, of course, doubtful, because before zero catch is arrived at there will either have been economic adjustments or the fishery will have ceased to exist. In any case, it will at first tend to be asymptotic with the zero base line.

So much for the *biological* effect on the stocks of successive increases in fishing effort (of the same kind), and it is here that the fishery-economist-administrator must take over, since it is obviously absurd to tolerate the situation so often encountered in which increased effort results in a serious decrease in yield. It is his task to correlate the social and economic factors so as to *modify* the fishing curve which would result from uncontrolled conditions. He will, first, in consultation with the biologists, try to determine at which point on the curve the addition of extra units of fishing effort should cease, and take the necessary administrative measures to this effect. He will

also, with the cooperation of fishery technologists, see to what extent improvements in gear, boats and fishing methods, and the discovery of new grounds, etc. may be expected to accelerate (and perhaps anticipate) the ascending part of the curve and delay or avoid the descending portion, although the possible results will vary greatly in each fishery. He may with the means at his disposal be able to approximate some such improvements as are shown in the hatched line in Diagram III, in which he will perhaps ideally be influenced by the desirability of the fishing curve becoming, in so far as is possible, asymptotic with a new, hypothetical maximum catch (dotted line), i.e., the "eumetric fishing" of authors.

Some of the specific economic factors which will influence the informed administrator, in addition to purely biological considerations, are given by Turvey (1957)[5], when he graphically illustrated the complexity of the parameters confronting the administrator in his analyses.

The upper part (i) of Turvey's Diagram IV shows the sustainable catch which will exactly balance the excess of population increase[6] over natural mortality, at different levels of exploitation. At population O there can obviously be no increase, and again at the maximum population F[7] there can, under conditions of saturation (equilibrium) and in the absence of pre-

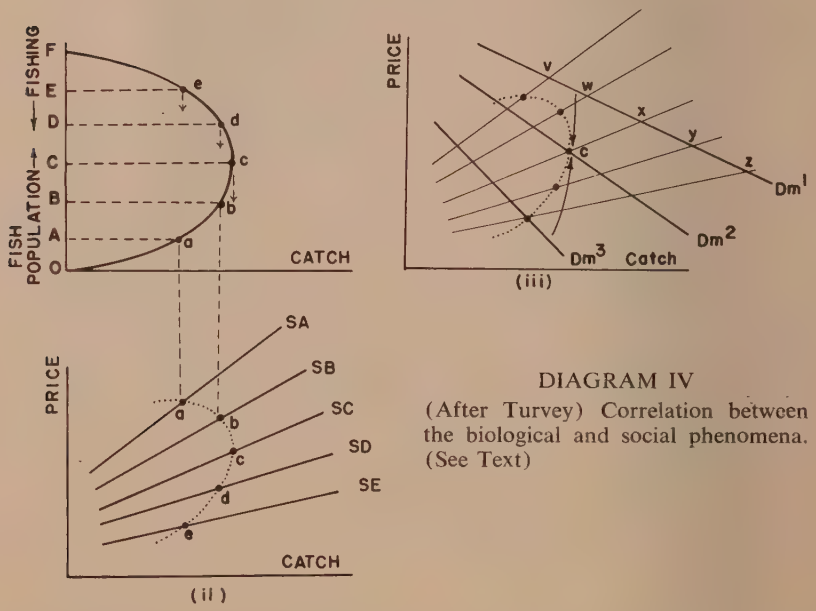


DIAGRAM IV

(After Turvey) Correlation between the biological and social phenomena. (See Text)

[5]For the purpose of this dissertation, Turvey's premises will not be discussed. The shape of the populations curve may be considered to be stylized.

[6]g+z-q, if all parameters are expressed in terms of instantaneity.

[7]This illustrates Ricker's point that "too much preoccupation with size of stock can lead to the (erroneous) assumption that a large stock is an end in itself . . . It is possible for a stock to be too great to provide maximum yield."

dation by man, again be no increase. At all intermediate levels, it is assumed that there would have been an expansion of the population in its attempt to achieve equilibrium, had it not been checked by fishing. At each point on the curve, other things being equal, there may subsequently either be a dynamic adjustment towards F (underfishing) or towards O (overfishing) and a static condition will exist at a given point only if fishing mortality equals the increase in population in excess of natural mortality. It is theoretically possible to strike a fishing point on the curve (around FC) which will take advantage of all the circumstances involved so as to give a maximum (but not necessarily the optimum) equilibrium catch, Cc. For the purposes of projection, this curve has been up-ended through 90°.

Projections ii and iii attempt to relate the social optima, under different conditions, to the competitive equilibrium described, for which purpose five of an infinite number of possible supply curves are drawn in projection (ii).

When there is (in (i), above) a balanced population OA at a maximum sustainable catch Aa, the only point on the supply curve corresponding to population OA which is sustainable under the prevailing natural conditions, is a in projection ii, and so on successively with points b, c, d and e. Hence, the dotted line which is the locus of these and intermediate points shows the set of combinations of price and catch which can be sustained while such natural conditions persist.

Now, supposing equilibrium to have been reached at FAa, between fishing and excess of recruitment over natural mortality, it is obvious that the *same* catch, e, could be maintained with the smaller fishing effort FE, that, subsequently, a *larger* catch (Dd, Cc) could be obtained by a *controlled* increase in fishing effort (FD, FC), and that the social cost of obtaining this saving would be, first, the temporary sacrifice of the catch necessary to allow the fish population to expand from OA to OE and then the acceptance of rational management techniques to permit the catch to expand from Ee to Cc. It should be noted that, in addition to fishing restrictions, some temporary form of marketing control may be required in order to strike the new equilibriums successively at FDd and FCc (or such intermediate point as the demand and other socio-economic factors may warrant).

In IV (iii) Turvey attempts to take his arguments a step further so as to include demand as a (possibly controllable) parameter. Assuming the prevailing demand to be represented by curve Dm′, lying for the whole of its length above the dotted line a b c d e (giving uncontrolled economic "markets" at v w x y z but sustained availability only at lower points, on the dotted line) it is argued that, with free entry to the industry, the community would be exerting more effort than that required, and extracting a portion of the stock which is too large to maintain equilibrium. The present writer concludes that this may represent the extent to which license fees (a quasi-rent) or other deterrents to consumption (e.g. a tax on certain types of fish) might be introduced (with due consideration for compensation of losers), or the extra demand may be satisfied through the favoring of the importation of supplies from other fisheries.

When, on the other hand, the demand curve Dm^3 cuts the dotted line *below* the point of maximum sustainable catch, its intersection with the dotted line coinciding with a corresponding supply curve (in this case SE at e), then,

the market demand being less than the sustainable maximum catch, measures (price subsidies, consumer education, improvement of marketing conditions, etc.) may reasonably be sought to improve the demand or otherwise influence the social optimum, again so as to bring it in line with the biological optimum c. The extent to which such promotion measures are justified may depend on the extent to which optimal welfare conditions are imposed as a matter of policy elsewhere in the economy, since it may be argued that the fisheries *per se* do not warrant a greater degree of management.

Before leaving the question of the factors (biological and socio-economic) which must be taken cognizance of in any enlightened fishery management program, it may be well to stress that the factors so far mentioned, while not always precisely measurable, do lend themselves to some sort of relative evaluation. The existence of additional, but more intangible considerations, which do not lend themselves to measurement by means of such models as those illustrated, should nevertheless be kept in focus. Some of these can only be expressed in terms of human needs and human suffering, as, for instance, a *need* for better nutritional standards, which because of limited purchasing power in "poor" (Kirby and Szczepanik 1957) communities cannot yet be translated into terms of effective economic demand. It is important that, as we approach the point of "take-off into self-sustained growth" (Rostow, 1956) through management of the economy as a whole, these needs should gradually become equated with demand. It is in these fields that the wise and forward looking administrator will keep in touch with the ends which are being pursued by workers in nutrition, labor relations and public health and welfare, to whom we should look to help us in bringing these more philosophical concepts into our long-term calculations.

Ways and Means

One of the principal objects in setting forth at some length a partial exposé of the multiplicity and the complex interrelationships of the biological, economic and social premises to which the fishery administrator must pay attention if he is to come up with the right answers, has been the hope that this paper may come to the attention of at least some government officials at the policy making level in countries where, because of an almost complete unawareness of the real nature of the problems, fishery development is being retarded by defective administrative and institutional action, or even complete lack thereof.

It was precisely with a view to remedying this type of situation that the majority of nations have associated themselves in numerous phases of United Nations activities such as the U. N. Economic and Social Council, with its Technical Assistance Board; Unesco, ILO, FAO and others. It must be stressed, however, that none of these activities can at present in any way be considered as tending towards world government, as is sometimes erroneously supposed, and assistance can only be given to sovereign nations when, having become aware of the need for technical skills and advice which are not immediately available at the national level, their governments formulate a specific request and include it in the limited annual budgets allocated to each country.

FAO—the Food and Agriculture Organization of the United Nations, with

Headquarters in Rome and outposted offices in Asia, Africa and Latin America—was conceived at an international conference at Hot Springs in 1943 and its Constitution was approved by 42 member nations in October, 1945, ante-dating the United Nations Organization itself by about one week. This number has now grown and will probably, as a result of action by the General Conference being held in Rome this month, shortly approach 80 member countries.

The governments associated in FAO are able to call on the Organization for advice at various levels; through the availability of data the compilation, publication and distribution of which is a continuing task at the Headquarters; through the assignment of members of the permanent staff to problems, usually of a general advisory nature, in order to determine requirements; and more specifically, the sending of specially hired experts for a more or less lengthy period to assist the government by working alongside and training the local officers; and through co-operative action brought about by international training courses, symposia and permanent committees or commissions. In the field of fisheries, FAO has so far organized four short term training centers—two of a general nature in Chile (1954) and Mexico (1957) and two of a more specialized nature in Peru (food technology, 1958) and Colombia (fish culture, February 1960), in addition to those held in other regions.

As far as international fishery commissions are concerned, more interest has been shown by the countries of Europe and Asia in the creation of such advisory bodies, than in Latin America, and this is perhaps principally due to the fact that, in the majority of countries, there is a greater lack of trained personnel which could profitably contribute to the discussions.

It is, however, part of the standing instructions of the FAO Secretariat to contribute to and assist in the work of other institutions engaged in the international field, among which we believe the Gulf and Caribbean Fisheries Institute to be performing extremely important work.

As has been stated, one of the principal obstacles encountered by FAO and its member governments, in promoting fisheries development, has been the lack of even partially trained personnel to work alongside our experts and carry the torch when their assignments expire. Without this continued effort, technical assistance loses a great part of its potential value, and there is little to be gained by governments in receiving what may be an excellent report, but which is filed away and does not result in an active national program.

Hence, we believe the training of fisheries personnel in under-developed countries to be the only key to real progress. Our experts are, however, confronted with the problem as to whether they should recommend the sending away of likely candidates for long, academic training, in which case their skills will only become available to the administration (supposing that a new government continues their employment and is willing to offer them a career commensurate with their professional attainments) after the expert has left the country, or whether we should settle for something less, in the nature of on-the-job training plus perhaps a short term in some institution abroad. The answer is, of course, that both are indicated, but only in a few cases at present are governments seized with the need for full basic training,

so that we are thrown back on to the expedient of seeking short term training of an essentially practical nature, to the exclusion of other academic requirements which are usually demanded by educational institutions which cater only to those working for a degree. We have found this question of obtaining purely technical education for promising young people who must carry the load until the necessary time required for full academic training has elapsed, to be an extremely difficult one, and we are hoping that our colleagues in the teaching profession may be able to throw some light on it for us.

SELECTED REFERENCES

Baranov, F. I.

1918. Bases Biológicas de las Pesquerías. (Transl. from the Russian) U.S.S.R. Fisheries Dept. Bulletin, Vol. 1, No. 1.

Bottemane, C. J.

1919. Principles of Fisheries Development. North Holland Pub. Co., Amsterdam.

FAO, Fisheries Division

1958. Fishery Programs in relation to Agricultural and Economic Planning. FAO Fisheries paper No. 10, June, 1958.

1958. Role of Government in Fisheries Development. FAO Fisheries paper No. 12, July, 1958.

1958. International Action in the Field of Marine Sciences. FAO mimeo., June, 1958.

Gerhardsen, G. M.

1957. A Note on Costs in Fisheries. Round Table, FAO Rome, 1957.

Hart, J. L.

1958. Some Sociological Effects of Quota Control of Fisheries. The Canadian Fish Culturist, No. 22, May, 1958.

Johnson, D. R.

1959. Management Techniques Now Available to Fisheries Agencies, Their Background and Use. Proceedings of a Conference, College of Fisheries and Dept. of Economics, Univ. Washington, Seattle.

Kesteven, G. L.

1952. The Socio-Economic Programme with Special Reference to Conditions in the Indo-Pacific Region. Proc. Indo-Pac. Fish. Council, Bangkok.

Kirby, E. S. and E. K. Szczepanik

1957. Special Problems of Fisheries in Poor Countries. Round Table of the International Economic Association and FAO, Rome.

Le Cren, E. D.

1958. Some Observations on Methods of Speeding up Fish Population Assessments. Special Publication No. 1. Int. Comm. N.W. Atlantic Fisheries, Halifax, 1958.

Marr, J. C.

1954. Biología Pesquera Marina. Lectures, 1st FAO Latin American Training Centre, Santiago, Chile.

McKenzie, W. C.
1959. Notes on Analysis and Problems of Application in Biological and Economic Aspects of Fisheries Management. Proceedings Conf. Univ. Wash., Seattle.

Ricker, W. E.
1954. Stock and Recruitment. Fish. Res. Bd. of Canada, Vol. 11 No. 5.
1946. Production and Utilization of Fish Populations. Dept. of Zoology, Indiana Univ. Ecological Monographs, Vol. 16, Oct. 1946.
1958. Handbook of Computations for Biological Statistics of Fish Populations. Fish. Res. Bd. of Canada, Bulletin No. 119.
1958. Some Principles involved in Regulation of Fisheries by Quota. The Canadian Fish Culturist, No. 22, May, 1958.

Robas, J.
1959. Government men—I hate 'em. World Fishing, Sept. 1959.

Rostow, W. W.
1956. The Take-off into Self-sustained Growth. Economic Journal, March, 1956.

Scott, Anthony
1956. Optimal Utilization and Control of Fisheries. Round Table, Rome.

Scott, Gordon, H.
1954. The Economic Theory of a Common-Property Resource — The Fishery. Journal of Political Economy.
1956. Obstacles to Agreement on Control in the Fishing Industry. Round Table, Rome.

Sprules, W. M.
1959. The Theory of Scientific Fisheries Management. Trade News, Ottawa, Dec. 1959 (in press).

Turvey, R.
1957. Introduction. Round Table Conference, Rome.

Wilder, D. G.
1958. Regulation of the Lobster Fishery. Canadian Fish Culturist, No. 22, May, 1958.

Young, J.
1959. In Hendersons Seafood Inc.—An Operation Designed . . . to Overcome Evils of Mishandling Seafood. Seafood Merchandising, Sept. 1959.

The Current Patterns on the Tortugas Shrimp Grounds [1]

F. F. Koczy, M. O. Rinkel and S. J. Niskin
The Marine Laboratory, University of Miami

Introduction

A study of the oceanographic environments of Florida Bay was started in January, 1959, in connection with studies of the life history of the pink shrimp (*Penaeus duorarum*) on the Tortugas fishing grounds. These studies have been carried out by The Marine Laboratory of the University of Miami, under contract with the Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service. The results which are presented will be only preliminary. This work was planned on the following assumptions. The main nursery grounds for the pink shrimp are in Whitewater Bay. The migration from the nursery grounds is presumed to follow a path from Whitewater Bay along the Keys to the Dry Tortugas and then going towards the northwest into deeper water of the Gulf of Mexico. This assumption is based mainly on the size distribution of shrimp caught on the fishing grounds north of the Dry Tortugas in western Florida Bay. The young shrimp then move from the spawning area into Whitewater Bay. As shrimp larvae are not believed to be able to follow a fixed migration route, it was necessary to study the current system in this area to establish the fact that shrimp can be transported between the spawning and the nursery grounds. To cover and study intelligently the environment, observations were made of the distribution of oceanographic parameters such as temperature, salinity and phosphate.

Background Data

The general current system in the area is shown in Figure 1 (Wennekens, 1959). This figure is based on material published by Leipper (1954) and Chew (1955). The main feature of this system shows a current which enters into the Gulf of Mexico through the Yucatan Channel; part of it penetrates in a northerly direction depending on the general hydrodynamic and meteorological conditions in this area. This branch current may penetrate very far into the Gulf of Mexico or may make only a short loop before it turns to the east and south and leaves the Gulf of Mexico between the Dry Tortugas and Cuba to join the main current to become the Florida Current proper. One of the general features of the distribution of salinity is a low salinity pocket (Chew, 1957) stretching more or less parallel to the Florida west coast about in the position of the shelf edge (Figure 2). Passing from this salinity minimum toward the Florida coast, high salinities are found, but very close to the coast salinities are lower again. By studying the distribution of the high salinity water, it was concluded that this water originates in Florida Bay. The low salinity near the coast is created by the run-off from Florida. This salinity picture does not indicate a strong current passing from west to east in the region in which we are interested. However, as the previous investigations were carried out in the northern part of the eastern Gulf in the region in which Red Tide occurred, no conclusions could be derived about the current pattern close to the Dry Tortugas. The low salinity pocket was explained as run-off from the Mississippi River. Further and more

[1]Contribution No. 266 from The Marine Laboratory, University of Miami.

FIGURE 1. Boundaries of water masses of the Gulf of Mexico, Straits of Florida and Bahama Islands.

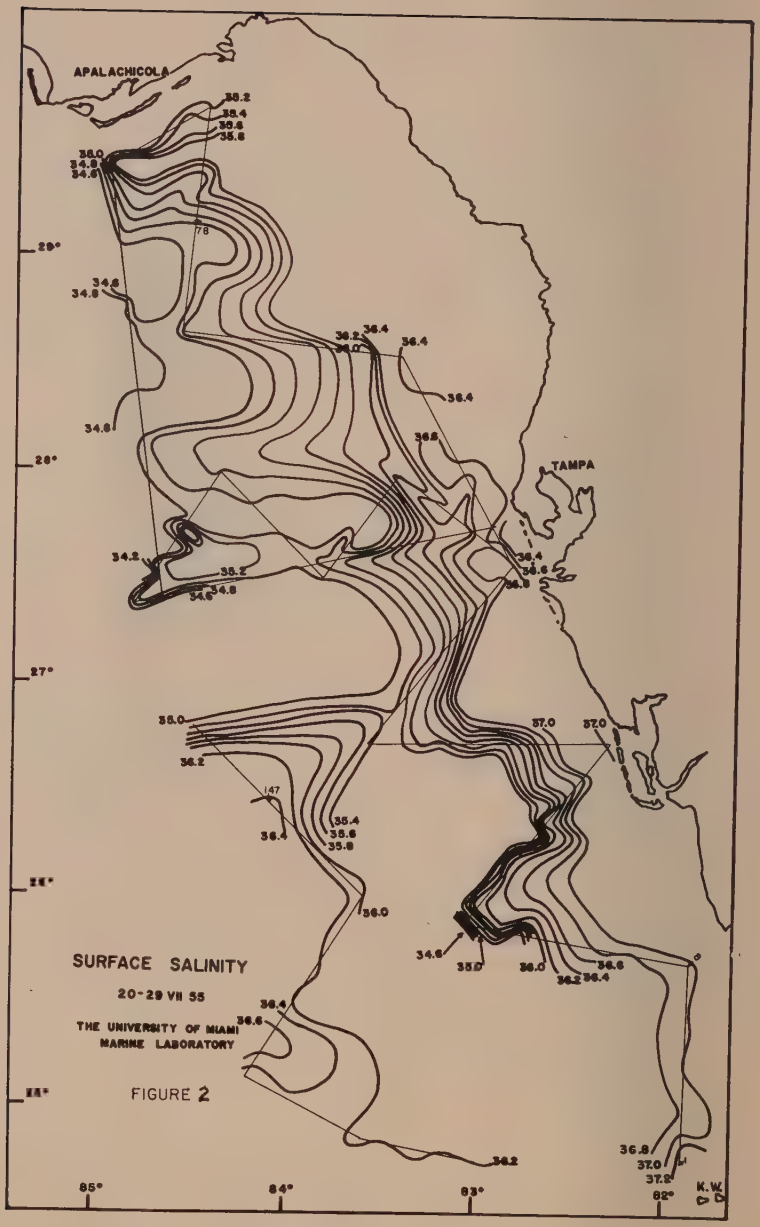


FIGURE 2. Surface salinities off the west coast of Florida.

intense studies about the permanency and the development of this low salinity pocket must be carried out before definite conclusions can be drawn. These investigations, based on a long term coverage of the area with a survey vessel and anchored recording buoys, would certainly contribute to the general oceanography of the Gulf of Mexico. On the other hand, it is believed that the influence of this special feature is not a serious one and that these preliminary conclusions, based on direct concrete observations, will be valid.

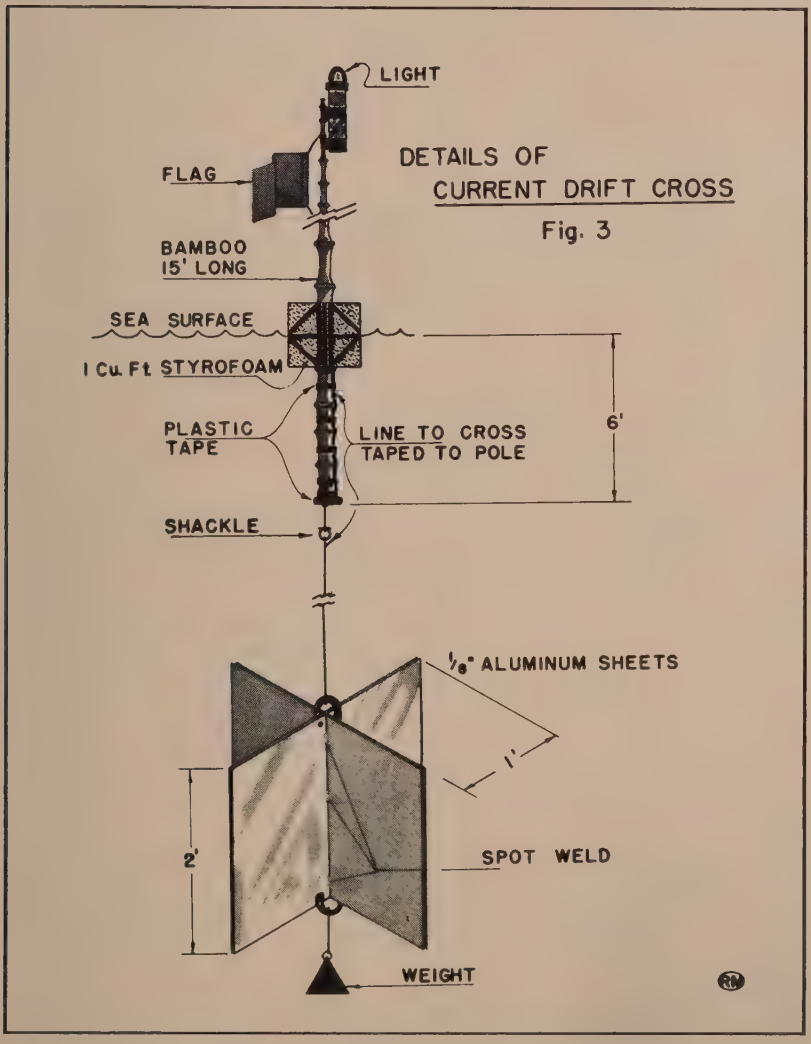


FIGURE 3. Details of current drift cross.

To attack the problem in the most efficient way and to achieve essential results applicable to fishery interests, an intense program of current measurements was organized; because, in general, the medium for the transport of the shrimp larvae is the water current. Of course it was necessary to study the distribution of salinity, temperature and density but it was felt that by developing a technique which gives adequate current data, the first logical assumption of the transport of the larvae could be proved or disproved. The main current in this region is the tidal current. Consequently at each current station a minimum of 1½ tidal cycles had to be observed to get the component of the permanent current. The best method to achieve this is to follow the paths of a water parcel over a given time period. Current crosses were utilized (Figure 3). The major problem encountered was the determination of the geographic position of the current crosses at half-hour time intervals.

Methods

After experimentation with several different methods, the following method for determining water movements was standardized. First a reference point, from which the geographical locations of the drifting current crosses could be ascertained, was established. This reference point was either a fixed navigation aid or an anchored radar reflector equipped "Hula Hoop" (Figure 4). Two aluminum 2 x 2 foot current crosses, equipped with flags and lights were then launched (Figure 3). One, a surface cross, was located 2 meters below the surface and the other, a bottom cross, usually 3 meters above the bottom. Using radar, a bearing and distance were taken at a time interval of one-half hour from each cross to the reference point.

When the distance between the crosses and the reference point reached about four miles, a second anchored reference "Hula Hoop" point was laid. This "leap frog" technique, as it was called, was extended as necessary to track the geographic location of the current crosses. Distance and bearing readings between the reference buoys were taken at time of laying and recovery. Based on cross checking of all bearing and range readings of the current crosses from any two reference "Hula Hoop" points, the largest geographical error recorded was 200 yards in distance and 10 degrees in direction at a cross reference point distance of four miles. The largest percentage of these multiple readings were much smaller in error. It is believed that the accuracy in the determination of the geographic locations of the current crosses is not in error by more than 200 yards in distance and 10 degrees in direction. It seems possible that a method error of 2 cm/sec can exist.

The "Hula Hoop" (Niskin, in press) consists of a ring 8 to 10 feet in diameter. This ring is formed from an 80 foot length of heavy walled 2 inch diameter polyethylene pipe wound round three times.

Its ends are joined with a standard 2 inch coupling of the same material. Twelve double nylon woven lines radiate inward from this ring to a brass hub. This hub is drilled to receive these nylon lines. The hub is milled to accept an aluminum mast 1¼ by 1¼ inches square and 20 feet in length. One third of this overall length is below the surface. Attached to the heel of the mast is a 30 pound heel weight. A 3-centimeter mesh universal life-raft type radar is attached to the head of the mast. An anchor line is made fast to the polyethylene ring and a 50 pound weight is used as an anchor.

Because the mast is suspended at the center of this large ring, it is very

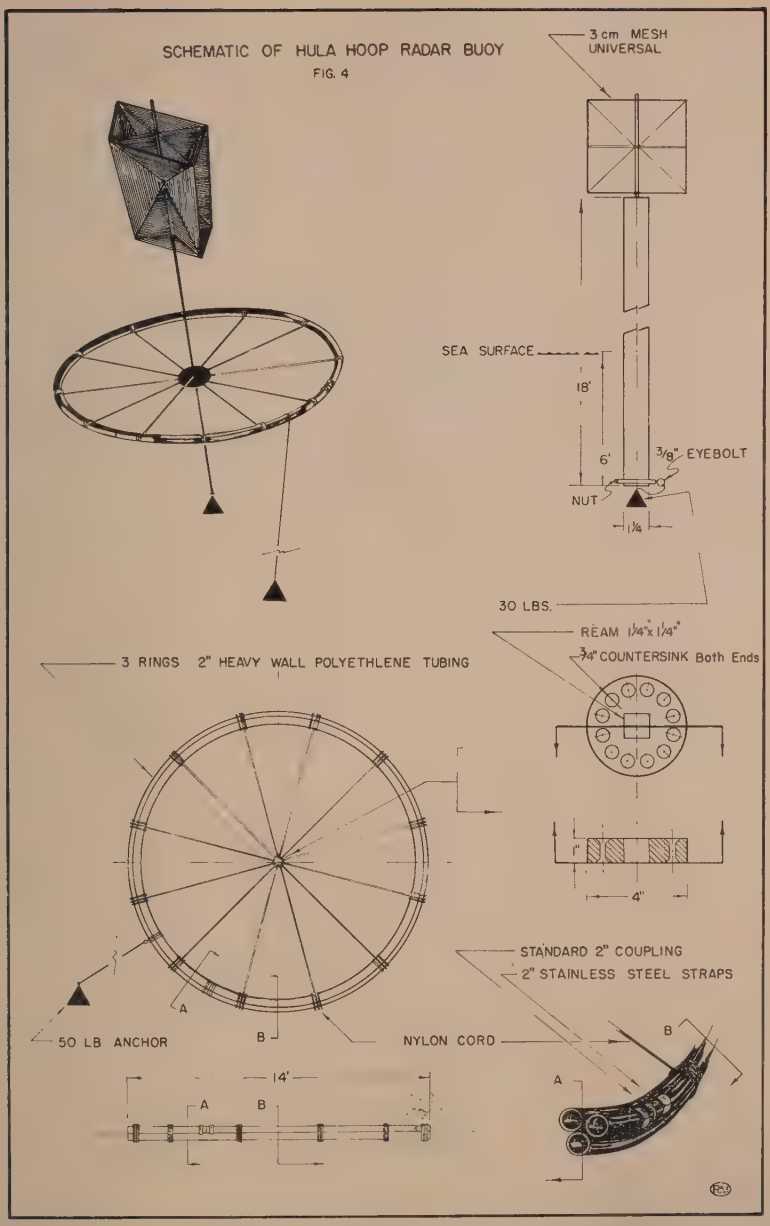


FIGURE 4. A schematic of the "Hula Hoop" radar buoy used as reference points on current stations.

effectively gimballed. The ring absorbs much of the vertical wave motion because the ring is flexible and the nylon spokes work and stretch. The above mentioned characteristics insure a maximum degree of vertical and overall stability of the mast.

The "Hula Hoop" has many other possible uses, i.e., surface current studies (minimum windage and cross suspension at the very surface of the water), suspension of surface instruments and gear, etc. The "Hula Hoop" is light (70 pounds, minus anchor and line), portable, easily launched and recovered and extremely seaworthy.

Results

The typical path of a surface current cross is shown in Figure 5. Each point gives the geographic position of the cross obtained at time intervals of usually one-half-hour. It is a classic example of a tidal elipse.

The average prevailing wind direction and speed is marked by arrows and is given in knots. On this occasion the water parcel seemed to stay stationary, except in the beginning of the observation, during which time it had a slightly southerly component. The permanent current was derived by assuming that the farthest point of the excursion either to the west or the east of the elipses, was the turning point of the tidal currents, and consequently should be at the same place in the absence of a permanent current. The times of the highs and

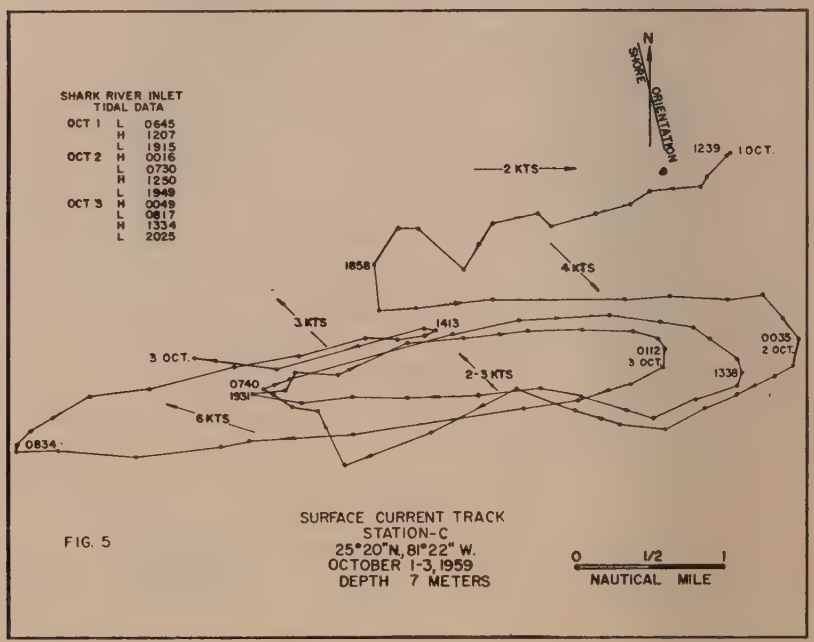


FIG. 5

FIGURE 5. Current track of the surface drift cross at Station C. Direction of cross movement is indicated by arrows. Times of high and low waters for Shark River Inlet 11.5 miles from Station C are indicated in upper left corner.

lows for Shark River inlet (11.5 miles away) are given in the upper left hand corner of Figures 5 and 6 and indicate the possible error in determining the turning point. The distances between these points established the direction and the speed of the non-tidal displacement of the water. If the displacement between two successive tidal cycles was approximately the same, this current was taken to be a good estimate of the permanent current. On the other hand, it is realized that the tidal variations may give erroneous results because of the variation of the tidal currents from one period to another. It is obvious that very small permanent currents will be measured with a considerable error, but for the purpose of the investigation it was only important to achieve an indication of currents to the east of a rather high speed. It is believed that the accuracy of this method is sufficient to determine the possibility of shrimp larvae transport from the spawning to the nursery grounds. Furthermore, we believe this method is the most simple and gives the best results. Improvement could be obtained only by increasing the time period over which the measurement is carried out.

At the same station simultaneous current measurements were made near the bottom (Figure 6). The tidal turning points of the surface and bottom currents were determined to be simultaneous, at least within the accuracy obtainable by the necessity of alternately measuring the position of both current crosses.

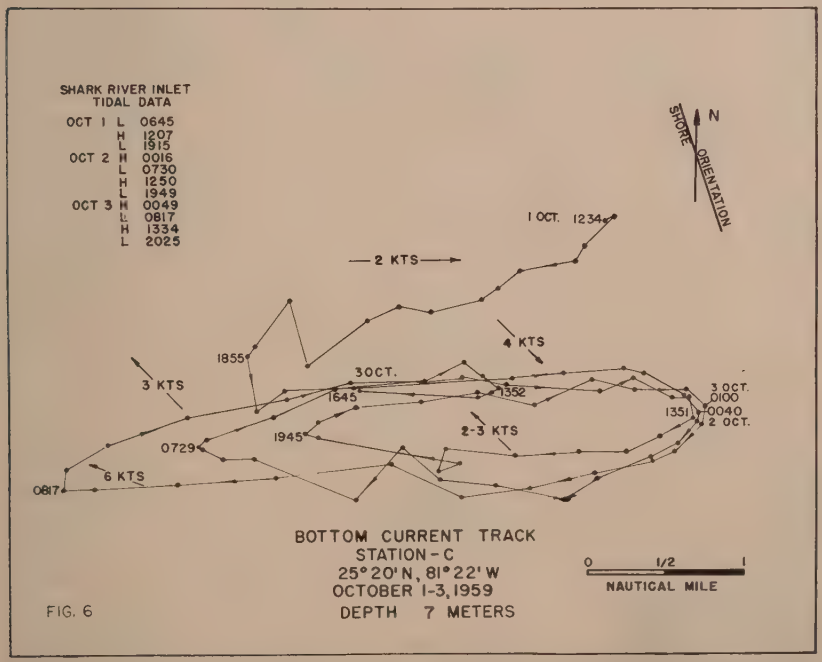


FIGURE 6. Current track of the bottom drift cross at Station C. Direction of cross movement is indicated by arrows. Times of high and low waters for Shark River Inlet 11.5 miles from Station C. are indicated in upper left corner.

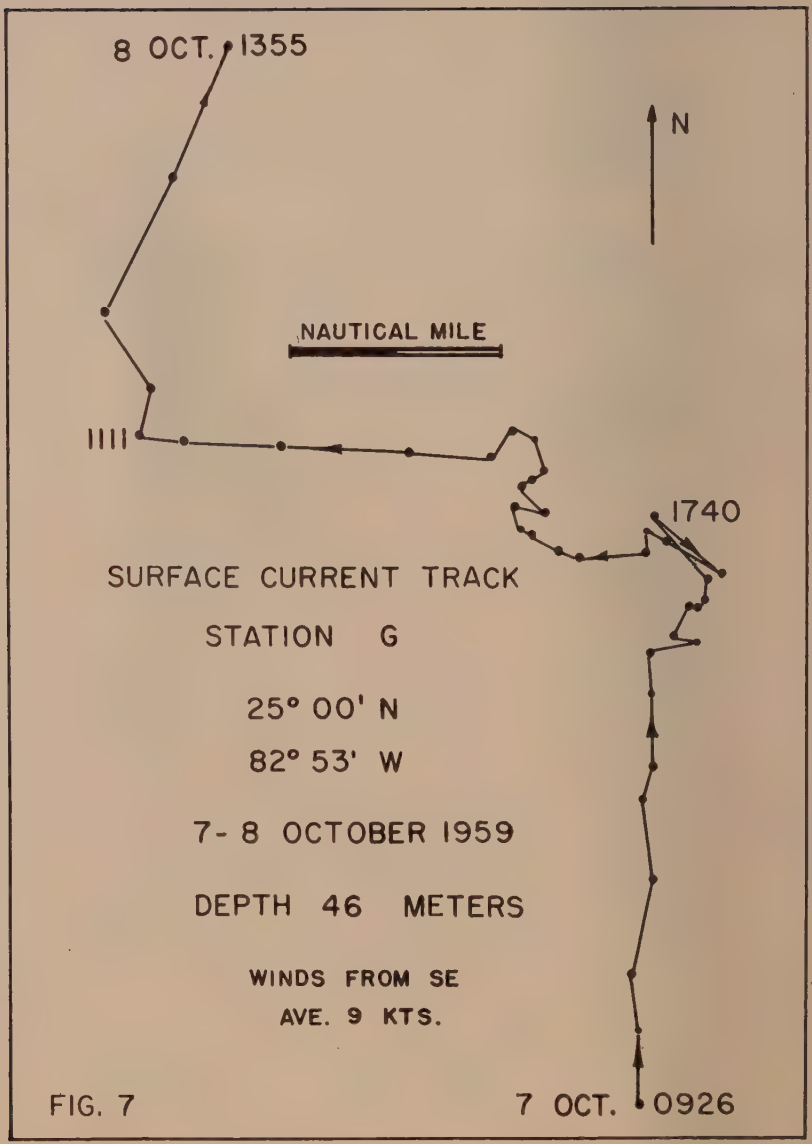


FIGURE 7. Current track of surface drift cross at Station G. Direction of cross movement is indicated by arrows.

The total tidal excursion between any two tidal turning points was about five miles at this station, which gives a tidal current of a little less than one knot in a nearly east-west direction. The smaller axis of the elipses was very small, less than mile. The permanent current at this station was determined to about 1/20th of a knot.

The situation given above is typical throughout the sampled area with the exception of three stations. At two of them, the bottom current was not similar to the surface current although both currents showed tidal characteristics. On the other station (Figures 7 and 8) no well developed tidal currents were found. Bottom and surface movement was slightly different. This may be explained by the fact that the bottom current cross was at greater depth than all other stations (50 meters), and in a slightly different water mass as shown by the difference between surface and bottom salinity of 0.6‰. The general trend of the movement of the surface buoy is at about 45 degrees to the right of the wind. The variations from a straight course do not seem to correspond to tidal excursions when compared with the nearest tidal data from the Dry Tortugas. The bottom current was, in the beginning of our series of measurements, about in accordance with the surface, but did show a marked decreased water parcel movement.

In total, eleven stations were occupied of which two were repeated as given in Table 1. The calculated permanent currents are shown in Figure 9. It is clear that these data are only preliminary, because of the scarcity of stations and of seasonal and yearly coverage.

The general trend of measurement of permanent currents from the surface and bottom current crosses indicates the existence of a pronounced westerly

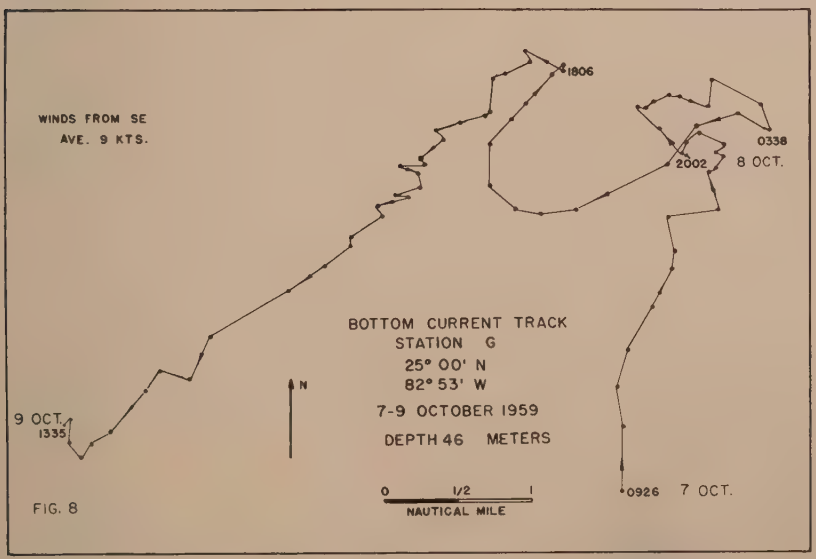


FIGURE 8. Current track of bottom drift cross at Station G. Direction of cross movement is indicated by arrows.

TABLE 1

RESULTANT CURRENTS FOR CURRENT STATIONS FLORIDA BAY SURVEY

Station	*Lat. N.*	*Long. W.*	*Month Occupied*	*Depth to Bottom (m)*	*Depth of Bottom Cross (m)*	*Surface*		*Bottom*	
						Direction	*Velocity**	*Direction*	*Velocity**
A	24° 45′	82° 42′	Jan. '59	31	29	210°	9.2	190°	6.2
B	24° 46′	82° 06′	Jan. '59	18	16	226°	12.1	223°	19.4
SG	25° 00′	81° 15′	Feb. '59	6	4	088°	2.0	070°	1.9
R-16	25° 40′	81° 39′	Mar. '59	7	5	299°	4.0	294°	2.1
WR	24° 57′	81° 46′	Mar. '59	15	7	050°	5.6	017°	5.4
			June '59	15	12	017°	7.3	027°	5.0
C	25° 20′	81° 22′	June '59	7	4	255°	5.8	262°	5.3
			Oct. '59	7	4	261°	6.1	252°	4.6
E	24° 30′	82° 38′	June '59	14	9	340°	7.3	326°	6.6
F	25° 10′	81° 45′	June '59	15	9	227°	2.1	114°	1.9
D	25° 10′	82° 14′	Oct. '59	29	20	291°	8.8	288°	8.1
G	25° 00′	82° 53′	Oct. '59	46	37	340°	9.4	279°	3.8
AB	24° 43′	82° 35′	Oct. '59	29	20	300°	11.4	286°	7.6

*Velocity in cm/sec and denotes average velocity through major tidal cycle.

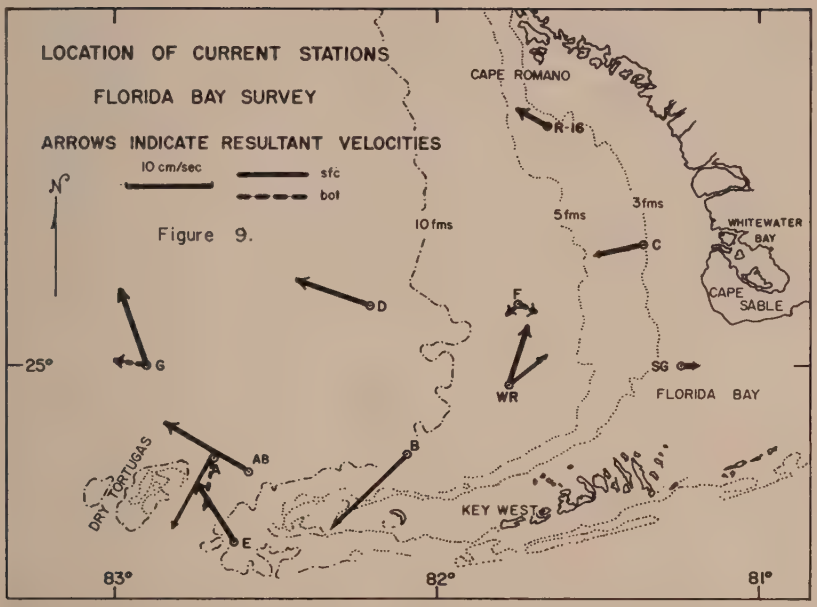


FIGURE 9. Location and resultant velocities of current stations Florida Bay Survey. Unless surface and/or bottom currents were markedly different, arrows represent average surface currents.

component in this region. There are only a few stations with easterly current. Moreover their speeds are so small, compared with the overall accuracy of the method, that it would be more appropriate to attribute a zero velocity to these stations. Generally this is true for all inshore stations. The inshore currents measured fall more or less within the range of accuracy of our method. The existing westerly currents cannot transport the larvae from the spawning area towards the shore, a distance of 100 miles in an easterly direction. Furthermore, even if the current direction were reversed, the distance could only be traveled in about 1000 hours or roughly six weeks, precluding the arrival at an inshore nursery ground.

All measurements have been carried out under essentially easterly and southeasterly wind conditions. This limits the results to weather of this type, which is the prevailing one throughout the year. During a westerly wave (westerly wind conditions) occurring during winter, the current flow pattern may be reversed.

Discussion

These preliminary results indicate that the prevailing current pattern cannot be responsible for the transport of larvae to Whitewater Bay. It was not possible to investigate other mechanisms which may be responsible for the transport. One could be a bottom current, as currents very close to the bottom may have escaped detection, since the method employed can only give the movement

of a rather thick water mass. Current crosses had to be positioned at least 2 feet above the bottom because of bottom irregularities.

Therefore, any bottom current transporting larvae in an easterly direction must be less than 2 feet thick. Theoretically it is possible that such a current exists; however, we do not believe it is probable. If such a current does exist, its speed is probably so small that it could not serve as a transportation medium for the larvae. However, in future work a study of the bottom currents will be included. It has been suggested that the shrimp larvae may have the ability to use the inshore leg of the tidal current for their movement. In order to do that, they need only to attach themselves to the bottom during the six hours the current is going towards the sea and float in the water during the inshore movement. As one tidal excursion is five miles in six hours, the larvae could make the whole distance in about four days. This problem is a purely biological one and has not been studied during our investigation.

Another possible explanation of the shoreward transport of larvae would be under easterly wave conditions, where for a short period of time a strong current could exist to the east. It is the authors' belief that under conditions like this the current is of short duration and the current speed could seldom reach values necessary to transport young shrimp into Whitewater Bay. However, this possibility has to be kept in mind during further investigations and a coverage of this area under all weather conditions has to be achieved. The best way to study this phenomenon would be by automatic current recording stations.

The rather high speed of the tidal current causes an intense mixing of the water masses resulting in a high value of the eddy diffusivity in this area. Preliminary calculations, which are based on diffusion constants in the Biscayne Bay and Florida Current, lead to the conclusion that the distribution of larvae has to show a very high gradient from the spawning grounds toward Whitewater Bay to allow the transport of the required amount of larvae to support the population of shrimp on the fishing grounds. Also in this case the time element would still be in the order of several weeks before the larvae could reach Whitewater Bay, a time period too long to substantiate this explanation. Before final conclusions about this possible solution can be derived, the distribution of larvae in this area has to be known both seasonally and yearly.

It is certainly premature to make any definite statements at the moment, but by summarizing these results, it seems virtually impossible to verify the mechanism by which larvae are transported to inshore areas from the conditions originally assumed. Thus, the assumptions postulated in the beginning of this paper will be again briefly discussed. These two basic assumptions made are:

1. Whitewater Bay is the primary nursery ground for all the larvae of the stock of shrimp in the Dry Tortugas area.
2. The larvae entering Whitewater Bay are produced in a spawning area about 100 miles off the western coast of Florida.

The first assumption is substantiated only by the high concentration of young shrimp in Whitewater Bay. Lacking knowledge of other possible nursery grounds, it cannot be stated that Whitewater Bay is the only existing one. Therefore, a part of the future study must include an investigation of potential nursery grounds of the shrimp. The conclusion that the principal spawning area is located to the northwest of the Dry Tortugas is based on the findings that the shrimp size increases from Dry Tortugas northward and that mature

shrimp have to be found in this area. That may be true, but the occurrence of mature shrimp in near-shore areas could be a satisfactory basis for the assumption that shrimp spawning near shore are the main source of shrimp larvae in Whitewater Bay.

This investigation has been organized according to the principle for fishery hydrography investigations as outlined by Koczy and Idyll (1957). We defined first, with help of the accessible data and the most logical conclusions, the problem and attacked it in the fastest possible way. As our primary assumptions are now doubtful, we must redefine the oceanographic problem with the help of new biological investigations. We hope by proceeding according to the given principle, we will be able to solve the hydrographic aspects of both the fishery and the biological problems posed by the shrimp fishery in the Dry Tortugas area.

This work was partially supported by the Office of Naval Research under contract Nonr 840 (01).

LITERATURE CITED

Chew, F.

1955. "On the Offshore Circulation and Convergent Mechanism in the Red Tide Regions Off the West Coast of Florida," Transactions of the American Geophysical Union, Vol. 36, No. 6, pp. 963-974.

1957. "Red Tide Studies," mimeo, pub., The Marine Laboratory, University of Miami, No. 57-18, pp. 1-14.

Koczy, F. F. and C. P. Idyll

1957. "Oceanography and Fisheries," Proceedings of the Gulf and Caribbean Fisheries Institute, Tenth Annual Session, pp. 107-112.

Leipper, D. F.

1954. "Gulf of Mexico—Its Waters, Origins and Marine Life," Fishery Bull. Fish and Wildlife Service, Vol. 55, pp. 119-141.

Niskin, S. J.

"A New Type of Marker Buoy for Oceanographic Research," (in press).

Wennekens, M. P.

1959. "Water Mass Properties of the Straits of Florida and in Related Waters," Bull. of Mar. Sci. of Gulf and Caribbean, Vol. 9, No. 1, pp. 1-49.

Potential for Developing a Red Snapper Fishery in British Guiana

FRANCIS TAYLOR
President, Warren Fish Company
Pensacola, Florida

THE ORIGINAL INVITATION asked that the subject of this talk be about the off-shore fisheries of British Guiana, but because of the finding of some shrimp off that coast this picture has changed to such an extent in the last year that anything that might be said in trying to cover the entire off-shore fisheries would certainly be out of date, so these remarks will be confined primarily to the Red Snapper Fishery.

First, for a very brief description of British Guiana or B.G. as it is affectionately referred to by the English in the West Indies, as well as those living in the country. It comprises a geographical area of about 89,000 square miles of which there is a coast line of approximately 270 miles on the Atlantic Ocean and which runs from South-East to North-West.

B. G. is situated between 1° and 8° North Latitude and 57° and 61° West Longitude and inland is bounded by Venezuela on the North and West Brazil and Dutch Guiana or Surinam on the South.

One more item of interest which should be mentioned because it does affect the fishing, and that is that Guiana means land of the waters and, due to the heavy rains in the area, there are a number of large rivers which bring large quantities of food to the Atlantic from the forests inland.

These rivers begin with the Courantyne River which separates B. G. from her neighbors on the southeast. Then the Berbice River flows into the Atlantic at New Amsterdam. Georgetown, the capital, is on the Demerara River. Perhaps the largest of all of the rivers is the Essequibo River which is some fifty miles west of Georgetown. Then from there north and westward to the Venezuelan border there are a number of smaller rivers, of which the Waini is the largest.

Lastly, there is a rise and fall of tide of some ten feet or more which is sufficient to make the rivers appear to flow up stream when the tide enters the large estuaries.

The author traveled quite a distance up some of these rivers and noted that they did not have the muddy appearance that they do near their mouths, so it is assumed that it is the constant changes in tide which stir up the mud in the estuaries and is responsible for the color given to the Atlantic for at least some fifteen miles at sea.

B. G. has two very capable Fishery Officers. At the present time, Mr. Eric Shepherd is designated as the off-shore Fishery Officer and Mr. W. H. L. Allsop has the responsibilities for the inland fisheries. However, during Mr. Shepherd's vacation several years ago, Mr. Allsop acted in his stead, so some of the present developments can be traced in part to the efforts of each or both of these men.

At the present time, Mr. Shepherd is in charge of the Government Fish Dock, and the off-shore operations. Mr. Allsop has a laboratory in the Botanical Gardens and is doing a great deal on fish culture to be carried out by farmers, etc. The Government Fish Dock is an idea which could well be copied by the fishing industry in the United States. Of course, the dock does serve as an unloading facility where the catches are unloaded and sold and where some of

the fishing boats remain berthed during their time in port. The outstanding feature is a very clean bunk house and a small cafe and game room where the fishermen who are in port can be comfortable while ashore.

Another reason why this facility is more than a convenience, and that is that in the case of the red snapper fishermen, most of them are from "The Islands" and were it not for this cafe and bunk room the men would have no place to go while ashore.

There seems to be good red snapper fishing all along this coast. The fishing grounds begin some fifty miles off-shore where the depth gets over thirty fathoms. However, from what could be learned, the fishing becomes better further southward along the coast.

So far there has been nothing said about the weather and fishing conditions. There is a very strong current which flows along this coast. The strength of this current never seems to be less than one knot per hour and runs at times as much as four times that strength. Also, there is the trade wind which also never seems to get discouraged and follows the path set by the current.

The red snapper fishing schooners are mostly longer than fifty-five feet and the sailing rig is either that of the schooner or modified ketch rigs. With but few exceptions, all vessels have auxiliary engines but in every case inspected, there is not sufficient power to satisfactorily handle the boat. Two trips were taken south eastward from Georgetown, which is directly into the wind and current and more than two days' time was required to travel less than one hundred and fifty miles.

The vessels are good sea boats and the crews are capable sailors, yet, under such conditions, in the final analysis the question is, "Are you going sailing or are you going fishing?"

Thus, the first prerequisite for improving these vessels would be to add more power. The next condition to rectify would be the installation of engine controls in the pilot house.

During the two trips made by the author from Georgetown, the captain had a small bell. The purpose of this was to call the engineer to him and discuss what he wanted to accomplish, and after that the engineer would run amidship, and dive in the engine room to do the captain's bidding.

As to the method of fishing, each fisherman operated one line which was usually fifty per cent longer than the depth in which the vessel fished. On the end of this line is a large chunk of iron. Up the line from this weight and about three feet apart are gangens carrying baited hooks. The number of hooks varied, perhaps from twelve to twenty or more. The method of fishing is to back the jib so that the boat cannot come into the wind. This allows the vessel drift beam to the current, and all hands man the fishing lines. While drifting thus and the lines cross a school of fish, nearly every fisherman will catch three or more fish, but no attempt is made to mark the location of that school of fish so the vessel drifts on until another school is encountered.

When the fish are brought on deck they are often treated in the same way as fishermen throughout the world react. That is, the fisherman is more interested in the fish that he hopes to catch rather than the fish he has caught. The result is, the fish are not put away as soon as they should be.

However, in most cases the fish receive excellent care. The next step is the way the fish are handled before being iced. The fish is ripped open along the stomach cavity and the entrails and gills are removed. Then the stomach lining

is scrubbed with fibers made from the palm leaves. This scrubbing is quite thorough and no blood is left in the cavity.

Now, unfortunately, another error is made. The fish are thrown down into the ice box, but the icer does not go below to cover the fish with ice until he has acquired at least one hundred fish. Of course, when fishing is good this is a comparatively short time, but should the fishing be poor, it may be as long as two days before the fish receive the benefit of the ice just below them.

It is believed that this procedure arose from the fact that the tools which were available for crushing ice were not very satisfactory, and the labor required to obtain crushed ice was quite excessive.

Our methods of fishing or handling of the catches are not always superior to the way it is being done in other parts of the world, and some worthwhile ideas can almost always be gathered from the other side of the globe.

For example, the method which B. G. fishermen use in cleaning the catch is certainly superior to the method used in the States. Another example is the incentive plan on which the fishermen work. The plan is an old one, and an idea which I have tried to get our fishermen to work, but without success. The idea being to pay the fishermen on count. The captain keeps an accurate record of the number of fish caught by each man and he is paid accordingly.

It must be admitted that fishermen get a rather rough deal in his share, for while he gets ten cents per fish, the owner of the vessel gets some forty or fifty cents per pound. Not a bad profit, even in the eyes of a shrimper.

There is one last criticism and that is the question of bait. The schooners go to sea with comparatively little bait and each fisherman uses some of the fish that he has caught. This fish is charged back to him at the price that he was allowed, but, unfortunately, this represents a substantial amount of the catch and a material financial loss to the owner of the vessel. Further the bait is not properly taken care of and much is lost due to the sun drying it out before it is put on the hook.

No details have been given about the red snapper fleet which fishes out of Georgetown. One reason is that there are some four or five boats owned in Georgetown and fully an equal number which are owned in the Islands and merely operate out of Georgetown. Further, it was my observation that by far the majority of the fishermen come from the many British possessions throughout the West Indies. For example, on the vessel that the author made trips, only one of the crew, and he was the cook, came from B. G.

There were other types of fishing being done. The first of which is done in the estuaries using large nets shaped like funnels. These nets are spread on poles which hold the mouth open in the direction of the outgoing or incoming tide. The catch from this net is harvested before the tide changes.

Then there are the pin seines. These are nets of some six feet high from corks to leads and they seem to be miles long. The method of setting them is from the beach out into the seas and back again nearly to the beach. These nets are set at high tide and as the tide recedes the fish are left on dry land from which they are collected by the fishermen. The fishermen who handle these nets have a most unusual type of boat, in that the length beam ratio is quite large. I would guess one of these vessels of some forty feet in length would have a beam of six feet more or less. None of these boats appeared to use engines. The sail used has quite a length from fore to aft, but because of the narrow beam, the mast is not high.

Lastly, there is the never ending search for shrimp. There was a company there by the name of the B. G. Fisheries, which spent quite a sum of money and built a rather elaborate shore establishment. It had very little success until Harry Sahlman and several others moved in with good equipment and now this has become quite a satisfactory operation.

Potentialities for an Octopus and Squid Fishery in the West Indies[1]

GILBERT L. VOSS
The Marine Laboratory, University of Miami

OCTOPUS AND SQUID, with their close relatives, the cuttlefishes, are heavily exploited for human consumption in many parts of the world. In the Mediterranean, India, China, Japan, the Philippines, Indonesia and Oceania they are considered to be one of the major delicacies obtained from the sea. Except for the first, these regions are mostly within the temperature boundaries found in the West Indies and with much the same habitat, yet, as we know, this source of food is hardly touched within the Caribbean region. The total world catch of cephalopods according to Walford (1958) is 1,800,000 metric tons, including all species. This is probably a low figure for a very large percentage of the catches are not included in the statistics from many countries. The largest producer of cephalopods is Japan which in 1952, its peak year, caught 646,000 tons, the average annual yield since World War II leveling off at about 600,000 tons of which nearly all are the common Japanese squid, *Todarodes pacificus*. The annual catch in North America is about 11,000 tons of which about 4,500 tons are taken in Newfoundland for codfish bait and are *Illex illecebrosus*. The United States catch consists of *Loligo pealei* and *Lolliguncula brevis* on the east coast and *Loligo opalescens* in California.

The author has made a rather extensive search of the literature and has questioned a number of individuals in an effort to determine the annual catch of cephalopods in the West Indies. Even considering that the majority of the catch is unreported, the fisheries must be considered negligible. Dr. Perez-Farfante of the Centro de Investigaciones Pesqueras in Cuba states (personal communication) that the 1958 production of squid and octopus in Cuba amounted to 20,472 pounds or roughly 10 tons. Mr. Erdman (personal communication) estimates the annual catch of octopus in Puerto Rico at about 50 tons, but squid are not obtained in commercial quantities. There are, apparently, no statistics from the island of Hispaniola. The Virgin Islands, with ample bottom and suitable habitat, are undoubtedly rich in octopus and squid, but Randall and Kumpf state (personal communication), after a year of underwater observations and fisheries survey work at St. John, that they have never seen an octopus or squid in the market or in local catches. Furthermore, a great fear and repugnance was shown by a native fisherman when confronted with a "sea cat" or octopus caught by the survey team. No mention is made, as nearly as can be determined,

[1]Contribution No. 257, The Marine Laboratory, University of Miami. This study was supported by National Science Foundation Grant G-5853.

of the occurrence of octopus or squid in the catches in the Leeward and Windward islands, although they are common there. If they are caught, it is probable that they are incidental to the other fisheries.

Drew (1919) reported that in 1912 there was a considerable fishery for octopus or "sea cats" at Montego Bay, Jamaica. However, both Stevens and Goreau of the University College of the West Indies (personal communication) state that they have never seen an octopus or squid in a commercial catch, although they thought that they might be caught on Pedro Banks. It is likely that the fishery has collapsed through lack of interest and the inroads of Canadian salt cod, highly esteemed by the natives.

Along the east coast of Central America no statistics are available. However, Hildebrand, in a personal communication, stated that in 1954 he saw two tons of octopus landed in a single day at a small town south of Vera Cruz, Mexico, where two Italians had started a local octopus fishery in the Mediterranean fashion. No further data are available to me on this region although the author was informed by reliable sources that the fishery is thriving.

Bermuda, although geographically outside the area under consideration, faunistically is a part of the West Indies. Squid are not taken commercially in the Bermudas but octopus are caught in small quantities and are eaten by the inhabitants of Portuguese descent. There are no established fisheries.

From this survey, two questions naturally arise. Are cephalopods worth eating? and, Do they occur in sufficient numbers to warrant a fishery? The answer to both of these questions is a qualified yes.

Cephalopods have been eaten in the Mediterranean and in the Orient for centuries. People of northern European extraction in general do not relish eating them due to an ingrained repugnance born of popular opinion. That this can be easily overcome, however, can be vouched for by the writer who relishes them whenever they are available. Akin to scallops or abalone in flavor, they are easily prepared in a number of interesting dishes. According to Leung, Pecot and Watt (1952) raw squid has 78 gram calories and dried squid 305 gram calories. Tanikawa (1952) analyzed the food value of seasoned and canned squid and found that 28.8 per cent of the whole animal was canned and that it had a food energy content of 117 gram calories.

Octopus differ considerably from squid in flavor, being much sweeter and, when properly prepared, very tender. Squid may be sold fresh, dried or canned in olive oil, and the flavor varies considerably. Octopus is usually sold fresh, but also may be dried. Octopus and squid figure prominently on the menus of most restaurants in Cuba and Puerto Rico, but their cephalopods largely come from Spain and Portugal in cans, called *Calamares en su Tinta*. Cuba imports about 606,157 pounds of canned squid annually from these two countries, valued at about $223,590.76 in 1958, a not inconsiderable sum in an island with an unfavorable import-export exchange. Erdman has no figures on imports in Puerto Rico but states that they are large and that both Spanish and Portuguese squid are found in the larger grocery stores, and that they are advertised on restaurant menus. He considers the Portuguese product to be superior in flavor. In Mexico, in the larger city groceries, octopus are packaged in cardboard containers wrapped in cellophane and sold fresh at the fish counters.

Cephalopods have always demanded a considerable price to the fisherman. Miss Thelma Jutare of the Bureau of Fisheries of the Philippines, presently at The Marine Laboratory at Miami, informed the author that squid in those

islands bring about two pesos per kilogram, or about 50 cents per pound fresh, or three pesos or 75 cents per pound dried. The fisheries there are still young and undeveloped and much of their dried squid is imported from Japan, although immediately after World War II the Monterey Bay, California, fishery supplied much of the demand.

While the price is not high in the West Indies, it still is higher than for many other marine species. In Cuba fresh octopus costs 40 cents per pound in the market (no figures are available for the price paid to the fisherman). In Puerto Rico the wholesale price according to Erdman was 12 cents per pound in 1954 but by 1959 had risen to 25 cents per pound. We can assume from the figures given here and above that there is a market for cephalopods. The next question is, Do they occur in sufficient quantities to support a larger fishery?

This is a difficult question to answer. It would seem, from the lack of statistics, that Cephalopoda do not occur in large enough numbers to encourage fishermen to hunt for them, and that the numbers taken are so small that the fishery statisticians ignore them. Let us take a look at the methods presently in use in the West Indies for capturing octopus and squid.

In Cuba, most of the squid are taken in fish trawls incidental to the scale fish. A few are caught using the cast net or *"atarraya"* and in Cienfuegos the *"poteras"* is employed. This is a lead, cone-shaped jig with upward directed barbless hooks at one end. This is sometimes baited with salt pork or a piece of cloth, and is jigged in the same fashion as in Newfoundland in the fisheries for *Illex*. Octopus are occasionally caught in fish traps but more often they are hooked out of their holes in the rock by means of a pole with a short hook which is thrust into a likely spot, turned and quickly pulled out along with the octopus. This is the same primitive type of fishery that is carried out in Polynesia, the Orient and along the coast of France and Italy. As in these other areas, when the surface is rippled by a breeze, the Cuban fisherman scatters a few drops of oil on the water to smooth it and aid in sighting the octopus. The octopus is killed by "turning the cap" or inverting the mantle by placing the fingers in the opening under the head and wrenching the mantle inside out, ripping loose the adductor muscles. This same method is universal wherever octopus are fished.

In Puerto Rico, according to Erdman, a few squid are caught in shore seines, but the largest catch noted was at Playhuela, Aguadilla, and amounted to only some 20 to 30 pounds of three to four inch squids. Octopus are caught in some quantity. At La Parguera there are about six part time octopus fishermen who make each about $1000.00 per year or about half the average annual income of a Puerto Rican fisherman. Their catch averages about 60 pounds a day. A good fisherman may catch as much as 100 pounds per day during the season.

The Puerto Rican octopus fisherman uses a crawfish grain or two tined spear which he pushes into a hole, twists and usually comes out with an octopus. They mainly fish along the windward side of the reef in about two to three feet of water. On the north coast the reefs are more cave like and a three foot iron rod is used with a barbless hook at the end. The catch here is much lower.

In the West Indies and Florida the season for octopus is from about October to March when the females come into shallow water to spawn. Erdman says that in Puerto Rico the season starts in July when small octopus occur on the reef weighing about 1/3 to 1/2 pound. By October octopus way weigh one pound or more and by February a number may weigh two pounds or better. From March to July the octopus fishery in Puerto Rico is nonexistent. November and

December are the months of greatest abundance.

As can be seen, the octopus fishery in the West Indies is extremely primitive and unproductive, and is limited to shallow water. In order to suggest better fishing methods, the octopus fishery in two distant areas might be mentioned. In Italy (Hornell, 1950) the octopus fisherman uses the *nassa* or *mummarella*. The *nassa* is a wicker lobster-pot like trap which the octopus can enter but cannot leave. It is baited with crabs and set in water down to 250 feet. The catch is fairly regular and large. The *mummarella* consists of a large number of earthenware pots *(lancelle)* tied at intervals of about 6 feet to a long line by means of short drop lines and staked or buoyed in likely areas. They are not baited but depend for their effectiveness on the proclivity of octopus to search out dark hiding places. The lines are hauled daily. In nearby Africa, earthenware drain pipes are laid side by side for over half a mile along the bottom (Lane, 1957).

In the Palk Strait area of India (Hornell, *loc. cit.)* a variation of the *mummarella* is used. The five finger conch, *Pterocera lambis,* is used in place of the pots. The long finger-like projections are knocked off, the apex broken off, and the shells tied to branch lines at intervals of 5 to 6 feet. As many as seven to nine hundred shells are tied to a single long line. These are set in a depth of 15 to 18 feet of water and hauled daily. As many as two to three hundred small octopus are caught each day in this fashion (Lane, *op. cit.).*

In the West Indies the queen or pink conch, *Strombus gigas,* is plentiful in many places and in most fishing villages the discarded shells are lying about in heaps in shallow water, a favorite haunt for octopus. These shells would, with no cash outlay, provide much better than the equivalent of the Palk Strait conch, and would be nearly as good as the Italian *mummarella.* Long lines of two to three hundred shells should be set outside the reef or in the deeper water of the lagoon from about six to about twenty or thirty feet, and after seasoning, should be pulled about every other day. It should be expected, in good areas, to have an octopus in about a quarter of the shells or even higher, after the proper depth and the right type of bottom have been ascertained. In the Florida Keys, Capt. William Grey of the Miami Seaquarium sets about 24 conch shells from which he receives about six octopus at a haul. He believes that the shells should be set out on broken shell or sand bottom away from the reef where too many natural holes are at hand. Personal observation leads the author to suggest that in the winter months the shallow grass beds would offer the best fishing areas. An energetic fisherman with his conch long line and only a rowboat could expect to triple or quadruple his output in this fashion, and the fishery would not be limited to the reef tract, permitting more fishermen to be employed. In addition, it would permit the industry to flourish throughout the year since fishing could be carried out in deeper water during the summer months, when the octopus move off shore.

Octopus are usually sold fresh locally and require good icing. When refrigeration is not available they may be dried. In France (Hornell, 1950), they are pegged out on lines in the fishermen's yards until dry, when they can be held for considerable periods of time. In California they are dried and exported to the Orient.

Squid may be taken in some areas by means of beach seines. The writer has seen commercial catches taken in this fashion from Piscadera Bay, Curacao. Along the south coast of Cuba squid are taken in shrimp and fish trawls. The

Florida fishing fleet, especially the shrimp fleet, takes them in considerable numbers on the Tortugas grounds, off Campeche and Honduras but they are considered trash and usually thrown overboard, except those that are saved for shipboard meals. The squid sold in the markets at Miami are shipped down from the north where they are taken in considerable quantities in the pound nets from Virginia northward. The catch is usually *Loligo* or *Lolliguncula,* but the writer has also purchased *Illex* in chain stores in Miami.

In Monterey Bay, California, there has long been a large squid fishery. In 1946 the annual catch was about 20,000 tons. In this fishery the squid are caught by means of the lampara net and also by purse seiners (Fields, 1950).

In areas where lampara nets and large purse seines are too costly, and simpler fishing gear is required, the former Monterey fishing method could profitably be used. In this fishery a skiff with a blazing torch in the bow was rowed about until a school of squid collected. The two accompanying skiffs or rowboats would set a small purse seine of about 180 feet in length and 18 feet deep. Considerable numbers may be taken in this way especially during the spawning period on the spawning grounds (Collins, 1892).

In Japan, where the fishery is carried out in a way more suitable to the West Indies, the vessels fish at night with 1000 watt lights over the side. The squid are attracted to the circle of light and then are either netted or, more usually, caught by swishing an artificial shrimp or other lure through the water. In this fashion a fisherman may catch thousands of squid in a single night. In the Philippines, lights are also used but the squid are caught in nets set around it or they are speared. The intensity of the light plays a large part in attracting squid. In the Philippines the light is alternately brightened and then dimmed. Harvey Bullis on board the *Oregon* using his fish bait trap beneath an outboard light found that for a few minutes after a red light was flashed on, following a white light, that the squid *Illex* came darting in under the light in great profusion. In a few minutes they would disappear and the red light had to be replaced by the white one for a short period of time.

Fresh squid require good icing or refrigeration in order to keep them for any length of time. Whereas fresh squid are largely eaten in Europe and America, throughout the Orient the squid are preferred dried, and most of the Japanese catch is sundried and then marketed both in Japan and abroad. This method is still carried out in a small way in California. This seems to be the best method for a small fishery such as could be developed in the West Indies, and might very conceivably be as profitable or more so than such fisheries as the dried conch exported from the Caicos Islands to Haiti. Squid are among the most numerous of all macroscopic animal life in the sea and the supply seems almost inexhaustible.

Six species of octopus are known from the shallow waters of the West Indies: *Octopus vulgaris, briareus, macropus, hummelincki, joubini* and *burryi.* Nothing is known about the edibility of the last three species, all of which are small. The larger species are *vulgaris, briareus* and *macropus.* The last named is apparently not numerous and seldom enters into the catches. *O. briareus* is common throughout the West Indies but is not very well liked. It has longer arms than the others and the body tends to be rather soft and flabby even when fresh. In Puerto Rico it is known as the *"madre de pulpo"* and while eaten it has no commercial value. In Cuba, *briareus* is known as *"fabiana"* and is considered to be somewhat toxic according to Dr. Aguayo (in lit.) who stated

that the fishermen believe that some persons have been made ill from eating it. *Octopus vulgaris* is variously known as *"pulpo,"* the "common octopus," the "rock scuttle" and the "sea cat." It is nearly cosmopolitan in distribution and is eaten wherever it occurs. It has a rather short life span, perhaps only two or three years. There is some evidence that it may live only for about one spawning season. Thus the supply should be good, and in areas where octopus are common, a heavy fishing effort may even be beneficial to the spiny lobster industry since they are known to eat lobsters and in years of heavy infestation of octopus on the English coast the lobster industry has very nearly been wiped out for several years (Rees and Lumby, 1954).

There are six potential commercial squids in the West Indies. These are *Loligo pealei* (the common squid), *Lolliguncula brevis* the brief or thumbstall squid, *Doryteuthis plei, D. brasiliensis, Sepioteuthis sepioidea,* and *Illex illecebrosus* the common squid north of Cape Cod and the mainstay of the Canadian fisheries (Squires, 1957). *Illex* is a surface dwelling squid in northern waters but follows an isotherm downward and in the Caribbean region is found at depths of around 350 fathoms. Night lighting however might be productvie for this species offshore as Bullis has found in his bait fishing on the *Oregon.* It occurs in tremendous numbers in the open sea and is the American counterpart of the common Japanese commercial species. *Loligo pealei* is found from Cape Cod to Venezuela but may be scarce in the Antilles. *Doryteuthis brasiliensis* is the commercial squid of Cuba, while *D. plei* may also occur. *Sepioteuthis sepioidea* is a compact, fleshy tropical species that has good possibilities. *Lolliguncula brevis* is smaller than the others, compact, fleshy and very common from Maryland to Argentina (Voss, 1955, 1956). It has good possibilities for canning purposes.

The commercial exploitation of the cephalopods is practically untouched in the West Indies and offers excellent opportunities to the small fisherman who cannot afford the large offshore gear for the scale fisheries. There seems to be a ready market in many of the islands, especially those with Spanish and French background. They are abundant in nearly all areas and small scale exploratory work should show that a sizeable industry can be developed.

LITERATURE CITED

Collins, J. W.

1892. Report on the fisheries of the Pacific Coast of the United States. U. S. Fish Comm. Rep. 1888: 3-269.

Drew; Gilman

1919. Structure and ejaculation of the spermatophores of *Octopus americanus.* Carnegie Inst. Wash., Publ. 28: 35-47, pls. 1-3.

Fields, W. Gordon

1950. A preliminary report on the fishery and on the biology of the squid, *Loligo opalescens.* Calif. Fish Game, *36*(4): 365-377.

Hornell, James

1950. Fishing in many waters. Chapter XV. Fishing for Octopus, Cuttlefish and squid. Cambridge Univ. Press. Cambridge.

Lane, Frank W.

1957. The kingdom of the octopus. Chapter X. Economic. Jarrolds, London.

Leung, Woot-Tsuen Wu, R. K. Pecot and B. K. Watt
1952. Composition of foods used in Far Eastern countries. Handbook U. S. Dept. Agri. No. 34.

Rees, W. J. and J. R. Lumby
1954. The abundance of *Octopus* in the English Channel. J. Mar. biol. Assoc. U. K. *33:* 515-536.

Squires, H. J.
1957. Squid *Illex illecebrosus* (Le Sueur) in the Newfoundland fishing area. J. Fish. Res. Bd. Canada, *14* (5): 693-728.

Tanikawa, Eiichi *et al.*
1952. Studies on the complete utilization of the squid *(Ommastrephes sloani pacificus).* Bull. Fac. Fish. Hokkaido, *3* (1): 73-94.

Voss, Gilbert L.
1955. The cephalopods obtained by the Harvard-Havana expedition off the coast of Cuba in 1938-39. Bull. Mar. Sci. Gulf and Carib., *5* (2): 81-115.
1956. A review of the cephalopods of the Gulf of Mexico. Bull. Mar. Sci. Gulf and Carib., *6* (2): 85-178.

Walford, Lionel A.
1958. Living resources of the sea. Ronald Press, New York.

Registrants

Gulf and Caribbean Fisheries Institute

Anderson, H. W.
Brunswick Navigation Company
Southport, N. C.

Anderson, Robert T.
Sea Pak Corp.
St. Simons Island, Ga.

Anderson, William W.
U.S.F.W.S.
Brunswick, Ga.

Arthur, Oswald Raynor
Governor of the Bahamas
Nassau, Bahamas

Bader, Richard G.
Dept. of Oceanography,
Texas A. & M.
College Station, Texas

Bailey, B. W.
5012 Yacht Club Road
Jacksonville, Fla.

Barnes, J. T.
Brunswick Navigation Co.
Southport, N. C.

Barr, James E.
Shrimp Assn. of the Americas
Brownsville, Tex.

Bates, Elizabeth N.
Sports Afield
New York, N. Y.

Beidler, E. John
Indian River Mosquito
Control District
Vero Beach, Fla.

Bevis, Charles
South Eastern Fisheries Assn.
330 So. Adams
Tallahassee, Fla.

Boerema, L. K.
F.A.O.
Panama

Brown, Aycock
News Director, Dare County
Tourist Bureau, Manteo, N. C.

Bullis, Harvey R., Jr.
U.S.F.W.S.
Pascagoula, Miss.

Burkland, Howard
Floramar Development Corp.
New Port Richey, Fla.

Campbell, Francis S.
St. George Packing Company
Fort Myers, Fla.

Castro, Fco. Javier Romo
National Chamber of Fishing
Industry
Mexico

Christianson, Charles E.
Bermuda Government Aquarium
St. George's, Bermuda

Croker, Robert
Marine Laboratory
University of Maimi
Miami, Fla.

Cubbage, C. M.
J. Howard Smith, Inc.
Port Monmouth, N. J.

deSylva, Don
Bayside Laboratory
Lewes, Del.

Dobkin, Sheldon
Marine Laboratory
University of Miami
Miami, Fla.

Drucker, Ben
Marine Laboratory
University of Miami
Miami, Fla.

Duggan, J. Roy
Sea Pak Corp.
St. Simons Island, Ga.

Dunton, Ammon G.
Reedville Oil and Guano Company
White Stone, Va.

Eckles, Howard H.
U.S.F.W.S.
Washington, D. C.

Envoldsen, Karl
Karl Envoldsen Company
Tampa, Fla.

Felton, Berlin E.
A & B Fish Company
Key West, Fla.

Ferguson, John C.
St. George Packing Company
Fort Myers Beach, Fla.

Ferreira, Hector
Pesquera e Industrializadora
de Guaymas
Guaymas, Son., Mexico

Friedman, Robert
Cape Haze Marine Laboratory
Placida, Fla.

Goodwin, Charles
Texas Game and Fish Commission
Port Aransas, Tex.

Gore, Wright W.
Western Seafood Company
P. O. Box 903
Freeport, Texas

Grandy, Robert M.
Alberti Seafoods Inc.
2009 Elmwood
Harlingen, Texas

Hardee, James B.
Standard Marine Supply Co.
Tampa, Fla.

Hargis, William J.
Virginia Fisheries Laboratory
Gloucester Point, Va.

Harrington, Robert W.
Florida State Board of Health
Vero Beach, Fla.

Herrington, William C.
State Department
Washington, D. C.

Hettler, Washington
Fishing Gazette
New York, N. Y.

Higman, James B.
Marine Laboratory
University of Miami
Miami, Fla.

Hodgson, Lionel T.
Booth Fisheries Corp.
Brownsville, Tex.

Holston, John A.
U.S.F.W.S.
Washington, D. C.

Howard, John K.
Marine Laboratory
University of Miami
Miami, Fla.

Idyll, C. P.
Marine Laboratory
University of Miami
Miami, Fla.

Janzen, Daniel H.
U.S.F.W.S.
Washington, D. C.

Jones, Albert C.
Marine Laboratory
University of Miami
Miami, Fla.

Kennedy, Thomas M.
Kennedy Marine Engine Co. Inc.
Reynoir & Jackson
Biloxi, Miss.

Kennedy, William Patrick
Kennedy Marine Engine Co. Inc.
P. O. Box 915
Biloxi, Miss.

Koczy, Fritz F.
Marine Laboratory
University of Miami
Miami, Fla.

Kriegel, Harry
Proseco International, S. A.
Nassau, Bahamas

Kuhn, Gilbert J.
Ocean Garden Products, Inc.
P. O. Box 3577
San Diego 3, Calif.

Leary, Terrance R.
Texas Game & Fish Commission
Rockport, Texas

Lentz, Henry R.
H. M. Hillman Brass & Copper
1600 Prytanea Street
New Orleans, La.

Letson, Stanley
Maine Marine Products, Inc.
Portland, Maine

Lewis, Euclid W.
Lewis Crab Factory
302 Reynolds Street
Brunswick, Ga.

Lord, David B.
H. L. Peace Publications
Jacksonville, Fla.

Ludwig, Charles
Ludwig Shrimp Company
Miami, Fla.

Lunsford, William C., Jr.
Reedville Oil and Guano Company
Wildwood, N. J.

McCann, Roland F.
Cat Cay Club
Cat Cay, Bahamas

McCarthy, Don
The Development Board
P. O. Box 818
Nassau, Bahamas

McGinnis, Harry I.
Empire Menhaden Company
New Orleans, La.

McPhillips, James
Southern Industrial Corp.
Mobile, Ala.

Maddock, Eleanor R.
New York, N. Y.

Madero, Mauricio
National Chamber Fishing Industry
16 de Septiembre 38-602
Mexico City

Magnusson, Harris W.
National Fisheries Institute
1614 20 St. N. W.
Washington, D. C.

Mahony, John
5200 S. W. 60 Place
Miami, Fla.

Malton, George B.
Amerio Contact Plate Freezers, Inc.
Union City, N. J.

Manning, Joseph H.
Department of Research & Education
Solomons, Maryland

Mehos, John
Liberty Corporations
Galveston, Texas

Miles, Cecil
Food and Agriculture Organization
Mexico 1, D. F.

Morgan, Daniel
Daniel & Dumas Sea Foods
P. O. Box 478
Port Lavaca, Texas

Morrow, James E., Jr.
Bingham Oceanographic Laboratory
Yale University
New Haven, Conn.

Neblett, William R.
National Shrimp Congress
Key West, Fla.

Olive, John R.
American Institute of Biological Sciences
Washington, D. C.

Parr, Albert E.
American Museum of Natural History
New York, N. Y.

Pesquera, Gilberto V.
University of Puerto Rico
P. O. Box 1952
Rio Piedras, Puerto Rico

Pettigrew, J. R.
Corrigan-Pettigrew Packaging Specialists, Inc.
P. O. Box 2883
Jacksonville 3, Fla.

Rae, Kenneth M.
Agriculture and Mechanical College of Texas
College Station, Texas

Randall, John E.
Marine Laboratory,
University of Miami
Miami 49, Fla.

Raney, Edward C.
Fernow Hall, Cornell University
Ithaca, N. Y.

Ray, Carleton
New York Zoological Society
Brooklyn, N. Y.

Ringhaver, L. C.
Diesel Engine Sales Inc.
St. Augustine, Fla.

Robas, Ann
P. O. Box 682
Fernandina Beach, Fla.

Robins, C. Richard
Marine Laboratory,
University of Miami
Miami, Fla.

Roman, Erl A.
Marine Laboratory,
University of Miami
Miami, Fla.

Rosenberg, John H.
Florida Fishermen's Supply Company
P. O. Box 547
Tampa, Fla.

Rounsefell, George A.
U.S.F.W.S.
Galveston, Texas

Ruppel, Albert James
Booth Fisheries De Mexico, S. A.
Ciudad Del Carmen, Campeche, Mex.

Russell, Oris S.
Department of Agriculture
and Marine Products
Nassau, Bahamas

Sahlman, Harry F.
Sahlman Seafoods Company
Fernandina Beach, Fla.

Sherman, Allen T.
International Fisheries Corp.
40 Worth St.
New York 13, N. Y.

Shreves, Melvin L.
Salt Water Sports Fishing
Association of Virginia
Bloxom, Virginia

Smith, F. G. Walton
Marine Laboratory,
University of Miami
Miami, Fla.

Snodgrass, Sam M.
Magic Valley Products Co.
P. O. Box 155
Port Isabel, Texas

Stewart, Kenneth
Marine Laboratory,
University of Miami
Miami, Fla.

Stewart, W. Adair
Canadian Embassy
Washington, D. C.

Strasburger, Lawrence W.
Food Technologist & Consultant
Metairie, La.

Styron, Jack T.
Wallace Menhaden Products, Inc.
New Orleans, La.

Taylor, Francis
Warren Fish Company
Pensacola, Florida

Thomassin, Maurice M.
Cia De Productos Crustaceos S. A.
P. O. Box 5263
Panama

Thompson, Paul E.
U.S.F.W.S.
Washington, D. C.

Thompson, Seton
U.S.F.W.S.
St. Petersburg Beach, Fla.

Tuinman, A. S.
Agricultural Attache,
Netherlands Embassy
Washington, D. C.

Van Cleve, Richard
University of Washington
Seattle, Washington

van Gelderen, Philip
Netherlands Embassy
Washington, D. C.

Varin, Clifford V.
Fire Island Sea Clam Co. Inc.
Atlantic Ave., West Sayville
New York

Versaggi, John
Versaggi Shrimp Co.
St. Augustine, Fla.

Versaggi, Virgil
Versaggi Shrimp Co.
Brownsville, Texas

Vincent, Dan B.
Dan B. Vincent Inc.
Tampa, Florida

Voss, Gilbert L.
Marine Laboratory,
University of Miami
Miami, Fla.

Wade, Richard A.
Marine Laboratory,
University of Miami
Miami, Fla.

Waller, Wayne M.
H. J. Baker and Brother
New York, N. Y.

Wanklyn, Lt. Col. Frederic A.
Agriculture & Marine Products Board
P. O. 933, Nassau, Bahamas

Warren, Zygmunt
National Chamber of Fishing
Industry
Mexico, D. F.

Wheeler, Murray
Shrimp Association of the Americas
Washington, D. C.

Wilmot, Morris D.
Gibbs Corporation
Jacksonville, Fla.

Wisby, Warren J.
Marine Laboratory,
University of Miami
Miami, Fla.

Xavier, Mal
National Fisheries Institute
Washington, D. C.

Zepeda, Manuel
Congeladora De Productos
Del Mar. S. A.
Prado Sor 540
Mexico